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A Toxicological Comparison of *Derris* and *Lonchocarpus*

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One of the main considerations, other than agronomic, in choosing among *Derris* and *Lonchocarpus* varieties for the production of insecticides should be the toxicological value of the product rather than the rotenone content. This fact was recognized by British buyers who purchased root on the basis of total extractives. American importers introduced the practice of buying on rotenone assay, but later some importers introduced the additional specification that there should be 3:1 ratio of total extractives to rotenone. However, it has been amply demonstrated by Jones *et al.*[3] that, of the various chemical criteria available for the evaluation of rotenone-bearing root, none, with the possible exception of the colorimetric determination of rotenone plus rotenoids, can be correlated with the toxicological value as measured biologically.

To determine in a preliminary way the differences between some botanical species and varieties with regard to toxicological value due to rotenone and other compounds, authentic samples of four types of *Derris* and *Lonchocarpus* were composited in such a way that final rotenone percentages of 5 per cent were obtained. These types were: the Sarawak Creeping and Changi No. 3 varieties of *Derris elliptica* (Wall.) Benth., *Lonchocarpus utilis* A. C. Smith, and *L. chrysophyllus* Kleinh. All of the roots were grown in Puerto Rico except these of *L. utilis* which were collected in South America.[4] The roots of three separate plants or groups of plants were composited to obtain each of the samples; two samples of *D. elliptica* var. Changi No. 3 were prepared, one containing 5 per cent and the other 10 per cent of rotenone.

At the time of weighing for rotenone (A.O.A.C. 1940) and moisture determination, 2.5000 gm. of each sample were placed in 250 ml. of acetone. This was swirled periodically for 2 days, cooled one-half hour in an ice bath, and filtered. Two hundred milliliters, taken after the extract had attained room temperature, were evaporated to dryness for use in the toxicological tests and part of the remainder was used for the colorimeteric determination of rotenone plus rotenoids (Jones 1944).

For toxicological tests the extracts were dissolved in acetone and diluted in such a manner that 1 ml. of test solution was equivalent to 2 mg. of root except that the sample of Changi No. 3 containing 10-per cent rotenone was doubly diluted. The tests were made by the turntable method on adult houseflies, duplicate tests being made on each of 3 days with approximately 150 flies to each test. In order to obtain numerical values for the toxicological rotenone equivalents[5] of the five unknowns, rotenone controls of 0.1, 0.2, and 0.5 mg. per ml. were run with the root-extract samples to establish a relationship between mortality and concentration. From this relationship the toxicological rotenone equivalents of the five samples were calculated.

The data obtained in the toxicological tests are presented in table 1.

In table 2 data are shown for total chloroform extractives, rotenone plus rotenoids, rotenone, and toxicological rotenone equivalent together with tabulated differences between the toxicological

[1] Federal Experiment Station, Mayaguez, Puerto Rico.

[2] Bureau of Entomology and Plant Quarantine, Beltsville, Md.

[3] Jones, H. A., Campbell, F. L., and Sullivan, W. N. Relation between chemical composition and insecticidal effectiveness of rotenone-bearing plants. JOUR. ECON. ENT. 28: 285–292. 1935.

[4] R. H. Moore of this Station and E. C. Higbee of the Office of Foreign Agricultural Relations furnished these samples.

[5] The toxicological rotenone equivalent of an insecticidal material is the percentage of rotenone the material would need to contain to give the kill actually found. The use of the term does not imply that the toxicity is all, or, even in part, due to rotenone.

Table 1.—Comparative toxicity to houseflies of *Derris* and *Lonchocarpus* extracts.

Source of Extract	Concentration	Mortality of Flies in 3 Days	Rotenone Equivalent of Test Solution	Rotenone Equivalent of Root
	mg./ml.	*Mean*[1] *Per cent*	*mg./ml.*	*Per cent*
D. elliptica var. Sarawak Creeping	2	57	0.280±.017	14.0±0.85
D. elliptica var. Changi No. 3 (low rotenone)	2	44	0.170±.012	8.5±0.6
D. elliptica var. Changi No. 3 (high rotenone)	1	42	0.160±.011	16.0±1.1
L. utilis	2	38	0.137±.011	6.9±0.55
L. chrysophyllus	2	34	0.119±.010	6.0±0.5
Rotenone[2]	0.1	31	0.100±.010	5.0±0.5
Rotenone	0.2	46	0.200±.016	10.0±0.8
Rotenone	0.5	74	0.500±.035	25.0±1.8

[1] Standard error of mean mortalities in 2.2 per cent. Differences among the mean mortalities greater than 6 per cent are significant at odds of 19:1.

[2] The rotenone mortality figures are extended to hypothetical roots containing only rotenone and handled in the same manner as samples 1, 2, 4, and 5.

rotenone equivalent and the three chemical criteria.

The data show that the *Derris* samples were relatively more toxic than those of *Lonchocarpus* of the same rotenone content. In other words, the extractives other than rotenone in the *Derris* were more toxic than those in the *Lonchocarpus*. The *D. elliptica* sample, var. Changi No. 3, low rotenone content, was on the border line of significance of being more toxic than *L. utilis*, thus indicating that the extractives in excess of rotenone are noticeably more toxic in the former. The first sample, *D. elliptica* var. Sarawak Creeping, showed the greatest toxicity due to substances other than rotenone. Variety Changi No. 3 of both high- and low-rotenone content were similar in that they showed practically the same relative increase in toxicological rotenone equivalent over rotenone. The *L. utilis* showed some toxicity due to extractives other than rotenone but the *L. chrysophylus* showed practically none. The latter was not significantly better than a sample from a root containing an equivalent amount of rotenone with no other toxic ingredients.

From the data it can be seen that, although the rotenone equivalent determination as shown by the red-color value was closely related to the toxicological rotenone equivalent, this chemical criterion varied from 14 per cent below to 38 per cent above the biologically determined value.

Conclusions.—On the assumption that these samples are more or less representative of the species and varieties considered

Table 2.—Analyses of 5 samples of rotenone-bearing root and the corresponding rotenone equivalent. (All data calculated to the dry basis)

	Total Chloroform Extractives	Red-color Value	Rotenone	Toxicological Rotenone Equivalent	Differences, Toxicological Rotenone Equivalent Minus—		
					Total chloroform	Red-color value	Rotenone
Derris elliptica var. Sarawak Creeping	16.8%	13.5%	5.7%	15.7±1.0%	−1.1%	2.2%	10.0%
D. elliptica var. Changi No. 3 (low rotenone)	12.4	10.2	5.3	9.4±0.7	−3.0	−0.8	4.1
D. elliptica var. Changi No. 3 (high rotenone)	22.3	18.2	10.0	18.7±1.3	−3.6	0.5	8.7
Lonchocarpus utilis	14.0	10.6	5.4	7.7±0.60	−6.3	−2.9	2.3
L. chrysophyllus	7.8	7.0	5.8	6.7±0.6	−1.1	−0.3	0.9

and that the toxicity to houseflies is a fair measure of the toxicological value of the sample, it appears that, other factors, such as root yield, etc., being equal, the Sarawak Creeping or the high-rotenone Changi No. 3 varieties of *Derris* would be the best choice for the production of insecticidal material.

In comparing the chemical criteria with the toxicological values, it appears that the colorimetric determination of rotenone plus rotenoids was the best chemical estimate of the toxicity of the samples, although it varied considerably from the biological evaluation.—3-8-45.

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DDT to Control Hide Beetles[1]

D. D. JENSEN and F. G. HOLDAWAY, *University of Hawaii Agricultural Experiment Station*

A study of the protection of rabbit skins from injury by hide beetles was undertaken because skins shipped from Hawaii to the mainland of the United States for felt manufacture were seriously damaged by these insects in transit. The species involved were *Dermestes vulpinus* Fab. and *Dermestes cadaverinus* Fab. The relative abundance of the two species varied somewhat. In one lot examined they were present in approximately equal numbers. In another lot *cadaverinus* comprised 70 per cent and *vulpinus* 30 per cent of the population sampled.

Under local commercial practice hides are dried out of doors for a period averaging four days. During this time they become heavily infested with adult beetles, which sometimes average over 30 per hide. Eggs are laid in the fur. The larvae, which hatch from the eggs in a few days, cause most of the damage by feeding on the skin.

Experiments on the control of hide beetle were conducted at Honolulu, T. H. After the hides had been dried at the rabbitry they were taken into the laboratory where they were wrapped in paper and held during the experiments. Untreated hides heavily infested with beetle larvae and adults served as the source of infestation for those experiments in which treated hides were exposed to continual reinfestation.

The materials tested for effectiveness of control were crude naphthalene, flake naphthalene, boric acid powder, camphor, paradichlorobenzene, and dust and spray forms of DDT (dichlorodiphenyltrichloroethane). Since DDT proved to be outstandingly superior to the other materials tested, the final experiments were restricted to the use of this substance. This report is confined to preliminary notes on the results obtained. A complete report on all materials tested will be published later.

DDT was used in five experiments. One type of study involved exposure of treated hides to continual reinfestation by larvae and adults throughout the duration of the experiments. In a second type, the treated hides were protected from reinfestation by caging after the initial exposure to ovipositing adults. Both series of experiments included (1) hides which had been dried and had become infested with beetles before DDT treatment and (2) fresh hides which were treated with DDT before drying and before exposure to beetle infestation.

Three rabbit skins were used for each treatment in four of the five experiments. In one experiment, only two hides were used per treatment. After the hides had been exposed to natural infestation and treated, those of each treatment were rolled together in medium-weight wrapping paper and held for examination at various intervals of time. In the experiments involving hides dried before treat-

[1] Published with the approval of the Director as Technical Paper No. 132 of the University of Hawaii Agricultural Experiment Station.

Table 1.—The effect of DDT on the development of hide beetles when applied to dry rabbit hides infested with beetle eggs and adults. After treatment the hides were protected from reinfestation.

Treatment	Infestation at Indicated Intervals After Treatment					
	21 days			42 days		
	Larvae alive	Adults alive	Adults dead	Larvae alive	Adults alive	Adults dead
3% DDT dust[1]	0	0	13	0	0	13
4% DDT dust	0	0	13	0	0	13
2% DDT spray[2]	0	0	13	0	0	13
4% DDT spray	0	0	13	0	0	13
Untreated check	150–200	9	4	68[3]	3	6

[1] *Gesarol A 20 dust* (a Geigy Company product) diluted with pyrophyllite.
[2] Technical grade DDT (supplied by Pennsylvania Salt Company) in kerosene.
[3] Hides 80 per cent destroyed.

ment, an equal number of live adult beetles was added to each package.

DDT dusts (diluted with pyrophyllite or talc) were tested at concentrations of 1, 2, 3, 4, 5, and 10 per cent. DDT sprays tested (DDT dissolved in benzene or kerosene) were at concentrations of 1, 2, 3, 4, and 5 per cent on a weight to volume basis. On dry hides the dusts were applied at the rate of 1, 2, and 3 pounds to 50 pounds of hides. On fresh hides approximately 5 grams were applied per hide. Sprays were applied to both dry and fresh hides at the rate of approximately 20 cc. per hide.

RESULTS.—In two experiments the rabbit hides were exposed during the drying period to an infestation of beetle adults and eggs, but, after treatment with DDT, were protected in cages from subsequent infestation. These experiments demonstrated that DDT dusts and sprays at all the concentrations listed above were sufficiently toxic to kill 100 per cent of the adults and also the larvae which hatched from the eggs. Table 1 presents the results from one such experiment in which 3 and 4 per cent dusts and 2 and 4 per cent sprays were used on dry hides infested with adults and eggs. All living adults were removed from the hides prior to treatment. Immediately after treatment, an equal number of live adults (13) was added to each package. The hides were thereafter protected from reinfestation.

The experiments involving hides treated with DDT dusts and sprays and exposed to continual reinfestation by adults and larvae revealed that the concentrations

Table 2.—Control of hide beetles with DDT when applied to fresh rabbit hides before drying and before exposure to beetle infestation. Hides exposed to continual reinfestation after treatment and after wrapping.[1]

Treatment	Infestation 17 Days after Treatment			Infestation 124 Days after Treatment			Infestation 272 Days after Treatment	
	Larvae alive	Adults alive	Adults dead	Larvae alive	Adults alive	Adults dead	Larvae alive	Adults alive
1% DDT dust[2]	3	19	14	0	0	21	0	0
3% DDT dust	0	0	12	0	4	12	0	0
5% DDT dust	0	2	15	0	6	16	0	0
10% DDT dust	0	0	9	0	1	44	0	0
1% DDT spray[3]	0	11	14	0	0	54	0	0
3% DDT spray	0	0	12	0	0	27	0	0
5% DDT spray	0	0	18	0	2	56	0	0
Untreated check	106	8	0	6[4]	7	0	0[5]	0

[1] The treated hides were dried before being wrapped. The wrapped hides were stacked together with the heavily infested check hides. Larvae and adults were able to chew holes through the wrapping paper or work their way around the folds of the paper thus gaining entry to the hides.
[2] *Gesarol A 20 dust* (a Geigy Company product) diluted with pyrophyllite.
[3] Commercially pure DDT in benzene.
[4] Hides 75 per cent damaged.
[5] Hides 98 per cent destroyed.

tested provide excellent protection from hide beetle damage for at least 371 days. Protection was not 100 per cent effective, however, at the lower concentrations. In these experiments no evidence of feeding was discernible on hides treated with 2, 3, 4, and 5 per cent sprays or 10 per cent dust. Five per cent of the hide surface was damaged by larval feeding during 357 days in one experiment testing 1 per cent spray. In another experiment (table 2) the same concentration provided complete protection for 272 days. One per cent DDT dust permitted slight damage on one hide and survival of three larvae long enough to molt. Dusts of 2, 3, 4, and 5 per cent concentrations did not provide 100 per cent protection from larval feeding when the hides were subject to continual reinfestation. However, the very slight amount of feeding which did occur during a year's time was negligible.

EFFECT OF DDT ON ADULTS.—Table 2 presents striking evidence of the toxicity to adult beetles of DDT dust at 10 per cent concentration and of DDT sprays at concentrations of 1, 3, and 5 per cent. These hides were exposed to continual reinfestation by adults and larvae. The first examination, 17 days after treatment, revealed that the number of dead adults found in each treated package was roughly the same with an average of 13 per package. No dead adults were found in the check package. The second examination, 124 days after treatment, revealed a great increase in the number of dead adults on the sprayed hides and on those treated with 10 per cent dust. The average for this group was 45 dead adults per package. This is an increase of 346 per cent between the first and second examinations. These dead adults represent transient beetles which invaded the packages containing hides treated with DDT but which died before they were able to injure the hides or leave the packages. The fact that fewer dead adults (27) were found on the hides treated with 3 per cent spray than on those treated with 1 per cent spray (54) cannot be explained with certainty. However, since the packages were stacked in a pile without regard to position, some may have been invaded by beetles more frequently than others. The increase in dead adults was only slight on hides treated with 1, 3, and 5 per cent dusts.

Table 3.—The effect of DDT on oviposition by *Dermestis vulpinus* Fab. and *Dermestes cadaverinus* Fab. as revealed by the number of dead first instar larvae per unit area of hide.

TREATMENT	APPROXIMATE NUMBER OF DEAD FIRST INSTAR LARVAE PER UNIT AREA OF TREATED HIDE
1% DDT dust[1]	100–150
3% DDT dust	80– 90
5% DDT dust	40– 50
10% DDT dust	15– 20
1% DDT spray[2]	30– 35
3% DDT spray	15– 20
5% DDT spray	10– 15

[1] *Gesarol A 20 dust* (a Geigy Company product) diluted with pyrophyllite.
[2] Commercially pure DDT in benzene.

Experiments were not conducted to determine the toxicity to adult beetles of benzene or kerosene in the absence of DDT. However, the circumstances under which the experiments were conducted make it highly improbable that the toxicity of DDT sprays was in any direct way due to these carriers. In some experiments the hides, after treatment, were dried in the open air for several days before being wrapped. Furthermore, the long periods of time during which the experiments ran should have insured complete evaporation of the carriers.

EFFECT OF DDT ON EGGS AND FIRST INSTAR LARVAE.—DDT did not prevent the hatching of beetle eggs. This was true regardless of whether the eggs were laid before or after DDT treatment. However, the young larvae emerging from the eggs were killed before they were able to do any perceptible feeding. This virtual complete mortality of first instar larvae occurred on all treated hides regardless of the concentration or form of DDT used.

EFFECT OF DDT ON OVIPOSITION.—Although DDT proved to be toxic to adult beetles, particularly in spray form and as a 10 per cent dust, oviposition was not completely prevented on hides treated before exposure to beetle infestation. The amount of oviposition, however, was inversely proportional to the concentration of DDT dust and spray applied. Since DDT did not prevent eggs from hatching, but killed the emerging larvae, the number of dead first instar larvae can be considered a valid index of the number of eggs laid per treated hide. In one experiment the approximate number of dead

first instar larvae per unit area of hide was noted during the first examination (17 days after treatment) of the hides treated before exposure to ovipositing adults. An exposed portion of the fur, approximately 40–50 square inches in area, was used in making the counts. The counts for each concentration of DDT are given in table 3 and indicate that sprays were much more effective in inhibiting oviposition than were dusts.

SUMMARY.—Experiments were conducted to determine the comparative efficiency of various materials in protecting rabbit hides from damage by larvae and adults of the hide beetles *Dermestes vulpinus* Fab. and *D. cadaverinus* Fab. Of the materials studied, DDT proved to be outstandingly superior to all others.

DDT, in spray and dust form, provided excellent protection for at least 371 days after a single treatment. Hides treated while fresh were as well protected for extended periods of time as were hides treated after they had been dried.

No evidence of feeding was discernible on hides treated with 10 per cent DDT dust or with 2, 3, 4, or 5 per cent DDT spray and exposed to continual reinfestation by beetle adults and larvae for 357 days. A slight though negligible amount of feeding took place on hides treated with 2, 3, 4, or 5 per cent dust. The maximum amount of damage suffered by hides treated with 1 per cent dust or 1 per cent spray did not exceed 5 per cent of the hide surface.

Sprays were found to be more toxic to adults than were dusts at the same concentration. Oviposition was not prevented on treated hides, but was inhibited in direct proportion to the concentration of DDT applied. Sprays were more effective than dusts in inhibiting oviposition. DDT did not prevent eggs from hatching. However, larvae which emerged from the eggs on DDT-treated hides were killed before they were able to do any perceptible feeding. All concentrations of dusts and sprays listed above provided complete kill of the first instar larvae.—2-11-46.

Biology and Control of the Ash Lace Bug, *Leptoypha minor*

ROBERT L. USINGER, *University of California, Davis*

Members of the genus *Leptoypha* differ from other common tingid pests in their brown coloration and compact body form and in the absence of lacy lateral lobes. The genus is widely distributed in the western hemisphere. Although commonly associated with the various species of ash (*Fraxinus*), *L. costata* Parshley has been taken on witch hazel; *L. elliptica* McAtee and *L. ilicis* Drake on *Ilex; L. nubilis* Drake on *Ceanothus; L. mutica* (Say) on *Chionanthus; L. mcateei* Drake on *Xolisma* and *Osmanthus*, and *L. minor* McAtee on *Populus candicans* and, according to H. H. Keifer, (in litt.) on an olive tree growing next to an infested ash tree at Los Banos, Calif., July 14, 1941.

The life history of the eastern *Leptoypha mutica* (Say) was worked out by Dickerson & Weiss (1916) on fringe trees, *Chionanthus virginica*, in a nursery where they were causing severe damage. These authors concluded that, "it is quite possible that there are two generations each season and that the adults hibernate."

DISTRIBUTION.—*Leptoypha minor* is the commonest species in California and has been recorded from Arizona. It occurs along the highways, in parks, and in the forests on the Arizona ash, *Fraxinus velutina* Torrey, and on the native *Fraxinus oregona* Nutt. It has been reported from the following counties in California: Glenn, Kern, Tehama, Yolo, and Yuba (H. H. Keifer) and from Tuolumne (R. L. Usinger). McAtee (1919) suggests that *L. minor* may be a synonym of *L. brevicornis* Champion but any conclusions on this point must await a detailed comparison with the type of Champion's species.

LIFE HISTORY.—(Fig. 1) At Davis, California, I have found hibernating adults clinging to the bark of ash trees throughout the winter. A few colonies of second and third instar nymphs were observed on May 10, 1941, after a very late, wet winter. Breeding was continuous from this time on until late in October. Eggs are partially embedded in the leaf tissue at the sides of veins on the under surfaces of

leaves. A prominent, oval, disk-like cap projects upward and is distinctive. The average length of the egg stage late in August in cellophane cages was 14 days. The five nymphal instars required 5, 7, 3, 3, and 6 days, making a total period of 38 days from egg to adult. It seems likely that the species undergoes 4 or possibly 5 generations a year in the vicinity of Davis, Calif. The population thus builds up to injurious numbers by late summer.

LAST NYMPHAL INSTAR.—Body oval in form, flattened above with the sides slightly reflexed and spined, upper surface entirely covered with erect, pale, tapering setae. Head a little broader than long, 16::14; clypeus convex, depressed at base, frons divided into a large, convex median plate which extends subtriangularly backwards to epicranial arms, and two lateral areas adjacent to inner margins of eyes and bases of antennae; frons with a pair of straight spines projecting forward and slightly upward from antero-lateral angles of median plate near bases of antennae, nearly as long as clypeus; a somewhat shorter median more erect spine just back of the anterior pair with briefly biramous apex; vertex divided at middle by posteriorly projecting epicranial arms, the arms following the median lobe of the frons and then abruptly bent lateral to inner posterior corner of eyes; an upward and slightly laterally projecting spine on each side of vertex just behind the bend in epicranial suture, these last biramous at apices. Bucculae thick, extending for the entire length of head, projecting downward about as far as width of an eye. Antennae about as thick as front femora, clothed with stiff, slightly anteriorly directed hairs which are about one-third as long as thickness of antennae; proportion of segments one to four as 4:4:11:9. Rostrum reaching hind margins of posterior coxae, basal segment and apex of third segment nearly as wide as thickness of front femora, second segment more slender, especially just beyond middle; proportion of segments one of four as 6.5:7:5:5.

Pronotum very large, laminately expanded laterally and angulately produced posteriorly at middle, about twice as broad as long, 39::20, the front margin straight, lateral margins arcuate, with five or six distinct spines, the humeral angles each with a closely approximate pair of prominent spines, posterior margins extending plate-like over much of the rest of thorax, angulately produced at middle between mesothoracic spines to metathorax; disk feebly convex anteriorly at middle beyond which the lateral lamellae are subdepressed and then slightly elevated toward lateral margins; a pair of short, stout, acuminate spines at middle near anterior margin and another pair near middle of disk. Mesothorax only briefly exposed on either side of pronotal projection, with a stout, acuminate spine on either side; mesothoracic paranotal pads well developed, laterally arcuately expanded, reaching fifth abdominal segment; lateral margins with about six prominent spines directed slightly upward and several smaller laterally directed spines, the most prominent spine at about apical third. Metathorax almost entirely exposed at middle, unarmed, its paranotal pads narrower and shorter than those of the mesothorax and hence concealed except narrowly near inner base.

Abdominal disk feebly convex medially, then subdepressed and broadly and very gradually elevated laterally, side margins interrupted by prominent, postero-laterally directed spines at postero-lateral angles of connexival segments; tubercles of ninth segment distinctly biramous, with numerous smaller setigerous tubercles between and beneath these main tubercles, tergites very gradually increasing in length from first to eight, the ninth much longer, half again as long as the eighth; second tergite with a pair of closely approximated, prominent, slightly divergent spines at middle of posterior margin; third and fourth segments each with a transverse slit at middle of posterior margin, these being the abdominal scent gland openings. Fifth, sixth, and eighth segments each with a stout, apically bifid tubercle arising at middle near the posterior margins.

Under surface feebly convex, laterally distinctly lamellate. Tarsi two-segmented, the basal segment very short, apical segment relatively long and swollen, bearing two claws.

General color ochraceous with brown juga, genae, vertex, lateral margins of frons, antero-medial elevated disk of pronotum including two pairs of tubercles, mesonotal tubercles and tubercles of abdominal terga, basal and apical thirds of mesonotal wing pads, and feebly elevated central abdominal disk. Under surface pale laterally except for dark longitudinal vittae along thickened inner margins of paranotal pads, brown along pleurites and sublaterally on abdomen with dark brown spiracles, pale along middle. Antennae white with faintly infuscated apices of terminal segments. Rostrum pale with brown labrum, setae, and black apex. Eyes reddish with a pale ring. Trochanters pale, femora brown with pale bases and apices, tibiae pale, tarsi infuscated apically.

Size of nymphs of each successive instar as follows: Head widths—.175, .241, .30, .375 and .425 mm.; body length—.583, .858, 1.1, 1.37 and 1.75 mm.

TYPE OF INJURY.—The nymphs live in colonies on the under sides of leaves. Their cast skins adhere to the leaf surface long after the bugs have matured and left. Other signs are the whitened leaf areas caused by the feeding of the bugs and the numerous black fecal spots (Fig. 2). I have never known *Leptoypha* to kill a tree, but at times nearly every leaf is covered with the bugs. At such times the entire foliage appears to be discolored.

CONTROL.—Various combinations of oil with nicotine, pyrethrum, and rotenone and lauryl thiocyanate were tried in control experiments (Table 1). In each case from 13 to 20 gallons of spray were applied to a tree. Counts were made after 24 hours, the number of live bugs per 3 feet of each of three branches of the sprayed tree being compared with the number of dead bugs in the same area. Inasmuch as the bugs adhered well to the tree, this gave a reliable indication of the per cent killed. Results given are averages of the

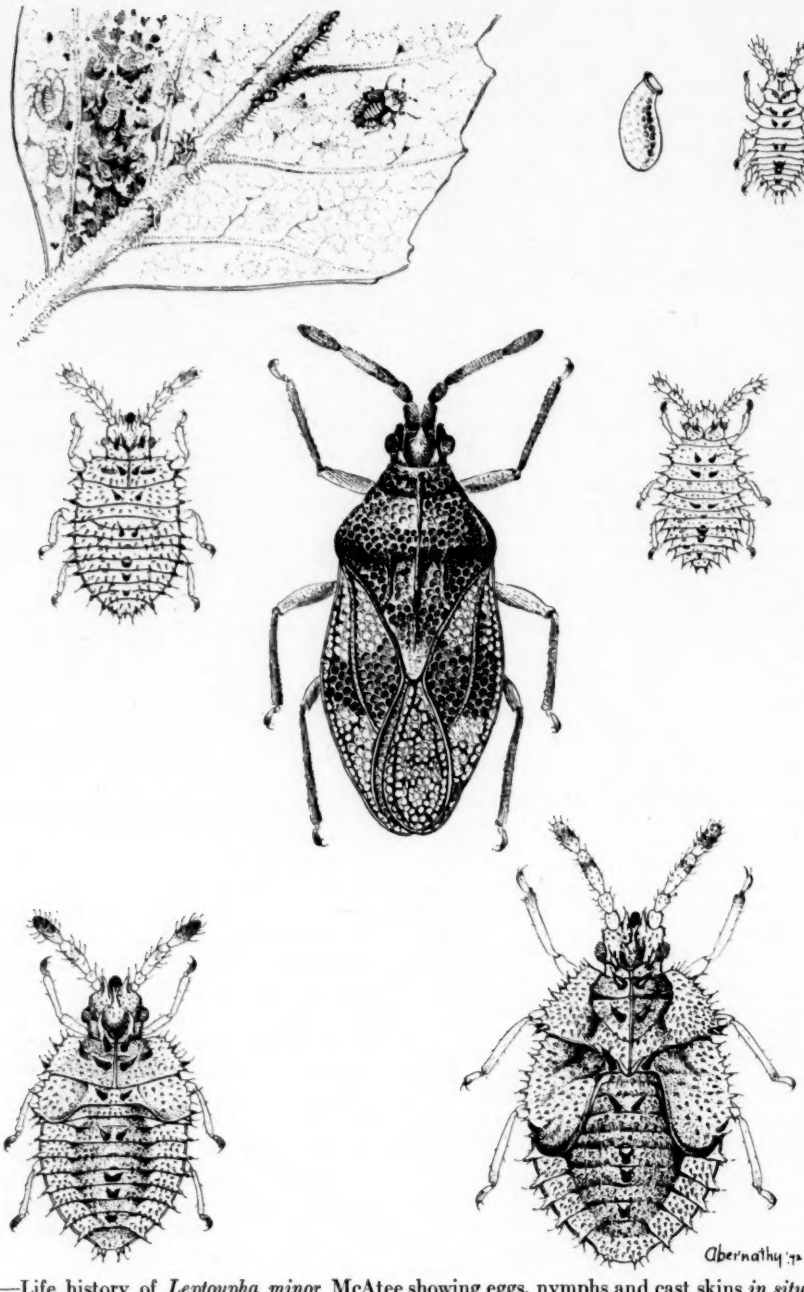

FIG. 1.—Life history of *Leptoypha minor* McAtee showing eggs, nymphs and cast skins *in situ*, details of an egg dissected from the leaf tissue, five successive nymphal instars and an adult.

per cent killed of each of the three samples from a single tree.

The nicotine-oil combination consisted of an oil emulsion containing 75 per cent by volume of petroleum oils and 25 per cent inert ingredients with 92 per cent U. R.[1] at a strength of 1 to 75, combined with nicotine sulfate[2] at 1 to 1200.

The pyrethrum-oil combination was the same as above but with pyrethrum con-

[1] *Arborol*, Calif. Spray Chem. Corp.
[2] *Black Leaf 40*, Tobacco By-Products and Chem. Corp.

Table 1.—Per cent kill of the ash lace bug, *Leptoypha minor*, with various insecticides.

INSECTICIDE	DATE OF APPLICATION	PER CENT KILL
Nicotine-oil	July 25, '40	93.8
Pyrethrum-oil	July 25, '40	78.2
Rotenone-oil-1-100	July 25, '40	100
Rotenone-oil-1-800	July 25, '40	100
Lauryl thiocyanate	July 25, '40	54.2

taining 2.5 per cent pyrethrins[3] at 1 to 1200 in place of the nicotine.

The lauryl thiocyanate[4] was applied at 1 to 400 with a spreader[5] in the same amount.

Best control was obtained with a rotenone-oil mixture consisting of 80 per cent by volume of a dispersing oil and 20 per cent of a derris extract in camphor sassafras base oil containing 5 grams of rotenone in 100 cc. The dispersing oil consisted of 75 per cent western olfene base oil and 25 per cent of a fatty condensation product (oleate).[6]

Even the most effective rotenone-oil sprays against nymphs and adults failed to kill the eggs as was evidenced by new colonies of young nymphs three weeks after the trees were sprayed. Because of the effectiveness of the rotenone-oil mixture when diluted 1 part to 800 parts of water, two applications are recommended at two or three week intervals for most economical control.

SUMMARY.—The ash lace bug, *Leptoypha minor* McAtee, differs from other common tingid pests in that it is brown in color and compact in body form without lacy lateral lobes. Adults hibernate during the winter in and around the trees. Eggs are laid on the under sides of the leaves beginning late in April after which generations follow one another continuously at monthly intervals until October. The population gradually builds up, attaining injurious numbers in late summer. The nymphs are flattened, spiny and gregarious, living in colonies on the under sides of the leaves. They pass through five stages, leaving their cast skins adhering to the leaf surface long after they have left. They cause a whitening of the leaves and a black spotting of the under surfaces due to fecal deposits. Both nymphs and adults of the lace bug were completely controlled with a rotenone-oil mixture at 1 to 800. From 12 to 20 gallons of spray should be used depending upon the size of the tree. Good coverage, especially of the under surfaces of the leaves, is essential.[7]—1-21-46.

FIG. 2.—Under surfaces of ash leaflets showing typical injury of *Leptoypha minor* McAtee. Cast skins and colonies of nymphs are present and the leaves are whitened from the feeding of the bugs and marked with black excrement spots.

[3] *Pyrocide 20 Deodorized and Clarified Liquid Insecticide.* McLaughlin Gormley King Co.
[4] *Lethane Junior,* Rohmand Haas Co.
[5] *Ortho Liquid Spreader,* Calif. Spray Chem. Corp.
[6] *Stantex Dispersing Oil, R-50,* Standard Agricultural Chemicals.

[7] *Acknowledgments.* J. D. Matley and W. A. Westgate of Standard Agricultural Chemicals, Inc. assisted with spray equipment and G. F. MacLeod, W. M. Hoskins, and S. F. Bailey of the University of California offered suggestions during the course of the work. H. H. Keifer of the California State Department of Agriculture supplied distributional data from state records. This assistance is gratefully acknowledged.

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Effect of Mineral Composition and Particle Size in Dispersants on Toxicity of Rotenone Dusts

H. F. Wilson and M. L. Jackson[1]

Results obtained from a study of mineral dispersants with rotenone indicated that mineral composition and particle size had a definite effect on the efficiency of rotenone dusts.

The main types of minerals studied were talcs containing a high percentage of magnesium and silica and pyrophyllite clays containing a high per cent of alumina and silica. In each group variable concentrations of combined magnesium or aluminum with silicon and small amounts of other constituents, particularly ferrous and ferric iron caused some variation in the per cent control of the pea aphid in greenhouse experiments.

In one preliminary study of a large series of mineral dispersants it was found that a sample of reasonably pure magnegium silicate talc from a deposit near Wausau, Wisconsin, was equal to, or slightly better than, any other talc sample tested. At the same time it was found that samples of aluminum silicate known as *Pyrax* (pyrophyllite, quartz, and mica) from a deposit at Hemp, North Carolina, was the most effective dispersant yet tested. However, when different samples of material from both deposits were tested, some consistently gave better control than others. When the samples were subjected to x-ray analysis for mineral composition and checked for average particle size, it was found that both were more or less variable and might account for the variations in control.

The average chemical analysis of *Pyrax*[2] and our analysis of the purest grade of Wisconsin talc showed the following per cent of elements:

	pH	S_iO^2	MgO	Al_2O_3	Fe_2O_3	TiO_2	CaO	Na_2O	K_2O	Ig. Loss
	6.9	73.94	0.02	20.15	0.07	0.5	0.06	0.2	1.54	4.0
Wisconsin talc	8.83	61.50	29.15	0.66	3.74	—	—	—	—	4.2

A series of samples of *Pyrax* and talc were then obtained and studied in detail as to mineral composition and particle size and subjected to biological tests with the pea aphid under greenhouse conditions with an average temperature range of 65 to 70° F.

Materials Tested.—The data given are based on greenhouse tests. Fourteen different samples were from the *Pyrax* mine at Hemp, North Carolina. Eight samples were from a talc deposit near Wausau, Wisconsin, and a sample of quartz crystals from the neighborhood of Little Rock, Arkansas. One sample of CP Fe_2O_3 was used to get data on the deterioration effects on rotenone with iron. The samples from the *Pyrax* mine were selected from a large number of available samples on the basis of the mineralogical content, and average particle size as shown both by the Fisher subsieve sizer and pipette analysis. Samples 1, 9, and 12 were tinted a light brown. Sample 9 was a portion of sample 1 reground to get a smaller average particle size. Sample 10 was a reground portion of 7. Sample 14 was a pink tinted quartz from a side wall of the mine ground to clay fineness. No 12 was similar in color to sample 1 but was taken from an open cut. It was used in the test series because of its large average particle size.

The talc samples were taken from piles of ore from excavated pits and represented the different types of rock that occurred in and along with the talc veins. The nature of these materials is indicated in the different test series.

Method of Making Tests.—In making toxicity tests a standard greenhouse procedure was followed to obtain control data. This consists of dusting plants under a bell jar with a weighed quantity of test dust. Each plant was infested with 15 aphids 24 hours before dusting and the plants were then covered with screen cages. When ready to treat, the cages

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[2] Furnished by the R. T. Vanderbilt Company, 230 Park Ave., New York.

were removed, the dust applied under a bell jar with 20 pounds air pressure, the cages replaced and the plants placed in the greenhouse for checking. Records of the dead aphids were taken at 24, 48, and 72-hour intervals. The data used here were based on the number of dead aphids at the end of 72 hours. A dosage of 200 milligrams of dust was used.

Experiment 1.—The purpose of this experiment was to determine if particle size and the content of pyrophyllite, quartz, and mica in *Pyrax* samples had any relation to the effectiveness of rotenone dusts when used to control the pea aphid. Nine samples of *Pyrax* ground to pass a 325-mesh screen were used for the test. A portion of sample 7 having a maximum particle size of 40 microns was reduced to a maximum particle size of 10 microns in a micronizer unit (sample 10).

The data based on ten replicated tests are given in table 1.

to 4.3 microns (subsieve sizer method) the results were not quite as good as when the average particle size was between 2.25 and 3.2 microns. When the average particle size was quite small, 1.39 and 1.4 microns a second trend toward low control is found. The latter trend was substantiated in numerous other laboratory tests wherein it was observed that decreased control follows a decrease in particle size. Similar trends are to be found in experiment 2.

Experiment 2.—The data given in table 1 were obtained during the winter period of 1943–44. To obtain additional data, a second series of tests were made in 1944–45. Ten samples were selected for study on the basis of average particle size. This included seven samples used in 1943–44, and three other samples giving a wider range of particle sizes including one of clay fineness and one with a high average particle size. Ground cube containing 4.6 per cent

Table 1.—Per cent control obtained with dusts containing 0.25, 0.5, and 0.75 per cent rotenone dispersed with Pyrax containing variable amounts of pyrophyllite, quartz, and mica, and ground to variable average particle sizes. Data obtained during October to April, 1942–43 and October to December, 1945.

Sample No.	Avg. Particle Size [1]	Avg. Particle Size [2]	Per Cent Pyrophyllite	Per Cent Quartz	Per Cent Mica	Per Cent Control 0.25% Rot.	Per Cent Control 0.5% Rot.	Per Cent Control 0.75% Rot.
1	4.0	17	40–50	30–40	15–20	77	77	80
2	3.72	16	50–60	30–40	10–15	86[3]	82	80
3	3.2	13.5	50–60	20–30	10–20	81	88	87
4	3.35	13	30–40	50–60	10–15	78	84	84
5	3.0	12	50	35–40	10–15	87	87	90
6	2.7	11	50–65	20–30	10–15	79	85	88
7	2.55	10	60–70	20–30	10–15	86	87	90
8	2.4	10	50	40	10	80	87	90
9	2.25	9	60–70	20–30	10–15	85	85	82[3]
10	1.4	7	50–60	30–40	10–15	80	81	83
11	1.39	7	60–70	10–20	20	80	84	83
	Difference required for significance					3.4	3.2	3.2

Samples 10 and 11 were portions of samples 7 and 3 ground to a superfine state.

[1] Average particle size determined with Fisher sub-sizer.
[2] Average particle size determined with pipette method.
[3] These figures are obviously out of line in this series. The true relationship is shown with a second series of dusts in table 2.

RESULTS.—An examination of the data show that considerable differences in pyrophyllite and quartz content had no effect on the degree of control. Within the experimental error to be expected in tests of this nature, six of the samples may be considered of equal value. Three samples gave relatively poor control.

Trends can be found to indicate that when the average particle size was 3.35

rotenone was used from the same lot used in experiment 1. The tests were replicated 10 times. The nature of the materials, and the control data, are given in table 2.

RESULTS.—No differences are to be found between samples containing variable amounts of pyrophyllite, quartz, and mica.

In considering the effect of particle

Table 2.—Per cent control obtained with dusts containing 0.25, 0.5, and 0.75 per cent rotenone dispersed with *Pyrax* samples of different average particle size.

Sample No.	Average Particle Size [1]	Average Particle Size [2]	Per Cent Pyrophyllite	Per Cent Quartz	Per Cent Mica	Per Cent Control 0.25% Rot.	Per Cent Control 0.5% Rot.	Per Cent Control 0.75% Rot.
1[3]	7.4	25[3]	—	—	—	53	60	64
1[4]	4.0	17	40–50	30–40	15–20	71	73	79
2[4]	3.72	16	50–60	30–40	10–15	70	78	80
4[4]	3.35	13	30–40	50–60	10–15	73	80	77
7[4]	2.55	10	50–60	30–40	10–15	77	80	87
8[4]	2.4	10	50–65	20–30	10–15	73	85	87
9[4]	2.25	9	40–50	30–40	15–20	77	84	85
13	1.9	8	50–60	30–40	10–15	70	73	78
10[4]	1.4	7	50–60	30–40	10–15	53	67	78
14	1.0	5	5–10	90–95	—	41	63	62
	Difference required for significance					3.9	3.6	3.5

Sample 9 was a reground portion of sample 1 and 10 was a portion of sample 7 ground to superfine stage.

[1] Fisher sub-sizer.
[2] Pipette method.
[3] Microscopic analysis.
[4] Taken from the same lot of material used in Experiment 1.

size, the differences found in experiment 1 are found to occur again in that three samples having an average particle size above 3.35 microns were poorer than the group with average particle sizes of 2.25 to 2.55 microns.

Samples 10, 13, and 14 having low average particle sizes showed a trend toward low control. Sample 14, a pink tinted *Pyrax* quartz ground to clay fineness has consistently given poor control with all concentrations of rotenone.

Experiment 3.—The purpose of this test was to determine the efficiency of rotenone dusts when dispersed with talc, with and without variable amounts of other minerals commonly found in talc deposits. Nine different samples were compared in the test series. The tests were made with samples passing through a 325-mesh screen and were replicated 10 times.

The purest grades of talc contained magnetic iron oxide which could be removed with a magnet. This talc was pale, translucent green in color and became white when finely ground. In other samples the iron had changed to ferrous or ferric iron and samples varying from light pink to a deep iron red and from light to dark green were selected for test purposes. Tremolite occurred in one sample; chlorite was common in another.

Two samples of quartz rock occurring in the ore body also were used. The nature of the materials, and the control data, are shown in table 3.

Results.—In this series pure quartz samples were found to be significantly better than all others. A mixture of 80–90 per cent quartz and 10 per cent talc high in iron content gave poorer control than pure quartz, and a mixture of 50 per cent talc and 50 per cent quartz with sufficient iron to give a deep red color gave very poor control.

The talc samples behaved in the same manner. Sample No. 1 was of a good white color with a slight grey tint due to particles of magnetic iron oxide. When the magnetic iron oxide particles were removed with a magnet, the talc lost its grey tint. Sample 2, containing just enough free Fe_2O_3 to give it a slight pink tint, was obviously poorer than the white talc, and No. 3 with a dark red tint was very poor. Sample 9 from a tremolite mineral seam between two layers of talc was light green in color with radiating crystal forms. The particles were distinctly fibrous, and like other materials of this nature, show wide differences in control with various per cents of rotenone. Sample 8 was taken from a chlorite mineral seam between layers of talc, was dark green in color and when ground to pass a 325-mesh screen broke down rapidly to contain many clay-size particles. When ground to particle sizes passing through a

Table 3.—Per cent control obtained with dusts containing 0.25, 0.5, and 0.75 per cent rotenone dispersed with samples from a Wisconsin talc deposit containing talc, quartz, and iron or chlorite.

Sample		Mineral Content			Percentage		Percentage Control with Rotenone Content of		
					Magnetic iron	Free iron			
No.	Description	Talc	Quartz	Chlorite	Fe_3O_4	Fe_2O_3	0.25%	0.5%	0.75%
1	White to light grey	90–100	—	—	3.5	0.19	75.4	80	85
2	Light pink	90–100	—	—	3.5	0.28	75	66.6	63
3	Dark red	90–100	—	—	3.5	0.66	55.2	47.7	47.5
4	White	—	90–100	—	0	?	83	84	93
5	White, pink tint	—	80–90	—	0	1.00	84	84	91
6	Red	10	80–90	trace	5–10	1.55	68	79.2	81.5
7	Deep red	50	50	—	3.5	4.65	51	63.4	72.1
8	Dark green	5	—	90–95	11	11.11	69	71	76
9	Light green	90–100[1]	—	trace	—	1.42	54	64	81
	Difference required for significance						4.62	4.1	4.53

[1] Tremolite.

200-mesh screen and held on a 325-mesh screen this material gave fairly effective control (Table 4).

The conclusions to be reached from this test series are in accord with numerous other observations. When Fe_2O_3 or FeO are present in a talc or clay they seem to produce conditions unfavorable to the best results with rotenone dusts. In the form of chloritoid particles, they are readily visable as dark anhydrous areas under the microscope. Chloritic materials are usually relatively high in iron, and are definitely poor dispersant materials when ground to pass a 325-mesh screen.

The explanation offered for this is that both ferric and ferrous iron have a tendency to break down into colloidal size particles and wherever these are found to any extent in a dispersant, poor results generally occur. Some samples of quartz have also shown a tendency to develop colloidal surface particles on larger particles after standing for some time.

Experiment 4.—Purpose of experiment was to determine the influence of mineral

Table 4.—The influence of mineral composition and particle size on the toxicity of rotenone dusts. The per cent control for each material is given in columns opposite the per cent of rotenone.

Particle Size	Per Cent Rotenone	Pure Talc	Pure Pyrophyllite	Standard Pyrax	Pyrax—Quartz			Pure Quartz Crystals	Chlorites
					Color white	Color grey	Color pink		
60–100	0.25	40	32	47	47	40	30	60	38
	0.5	57	43	48	74	47	43	80	51
	0.75	60	47	60	84	47	43	84	57
101–200	0.25	47	30	60	64	50	37	69	67
	0.5	62	38	58	80	57	47	76	76
	0.75	60	44	64	95	57	54	84	77
201–325	0.25	45	38	70	70	60	73	77	77
	0.5	63	35	76	75	57	75	77	80
	0.75	70	45	80	87	63	70	85	80
326 and less	0.25	57	46	70	74	60	83	74	54
	0.5	61	49	76	80	73	83	92	56
	0.75	64	53	76	83	80	80	93	64
Superfine	0.25	34	could	55	60	67	27	65	48
	0.5	54	not	61	64	67	57	68	57
	0.75	60	grind	67	60	60	60	78	63

composition and particle size on the toxicity of rotenone dusts in a particle size range from 60 to 325-mesh and the 325-mesh sizes ground to a superfine stage.

The talc, pyrophyllite, chlorite and clear quartz were of the highest quality available as determined by x-ray analyses. Some magnetic iron oxide was removed from the talc with a magnet.

The *Pyrax* was a standard grade and the *Pyrax* quartz samples contained approximately 10 per cent pyrophyllite, 80 to 90 per cent quartz and 5 to 10 per cent mica. One sample was slightly tinted grey, a second slight pink, and a third was clear white. The clear quartz crystals were approximately 100 per cent SiO_2. The test samples were obtained by taking a single piece of rock and grinding by mortar and pestle to pass the screen sizes indicated. The data given are based on seven replicated tests made during two winter periods from October to April, 1943 to 1945.

RESULTS.—Additional comparisons might change the relative position of one or more materials, but on the basis of past observations the trends would remain the same.

Clear quartz crystals without impurities other than magnetic iron have consistently given better control than any other material tested. Even very slight quantities of other minerals tend to reduce the control as indicated in table 4. White *Pyrax* quartz having some pyrophyllite but no iron oxide is equal to pure quartz in the larger particle size ranges but less so with particles less than 325-mesh screen size. Grey and pink tinted *Pyrax* quartz containing some iron oxide and standard *Pyrax* containing pyrophyllite and mica did not give as consistent results as white *Pyrax* quartz.

Pure pyrophyllite, which is the stem ore from *Pyrax*, is quite different from *Pyrax*, being made up of flaky particles very hard to grind to extreme fineness. We have never been able to get consistently good control with samples of pure pyrophyllite. The results with pure talc were unexpectedly low but fit into the general pattern previously found to occur between quartz crystals, *Pyrax*, pyrophyllite, and talc, The chlorite appeared to be better in these tests than in others and the data for screen sizes less than 325-mesh do not appear to be consistent with the results obtained in table 3.

These differences can be explained on the basis of grinding the material. When the samples of ore used in experiment 3 were ground, the whole sample was ground to pass through a 325-mesh screen. There was some quartz present and although ground to 325-mesh screen size helped to hold up the average particle size. When the sample used for the tests in experiment 4 was ground, the larger particles were separated first and the portion of each separation probably contained a larger portion of quartz crystals above the 325-mesh screen size. In the grinding, the chloritic material separated first and passed through all screens to the bottom pan where a sufficient amount was collected for the tests before the mass grinding for the 100 and 200-mesh screen sized particles was finished. This resulted in a larger amount of colloidal particles per unit than in experiment 3. Little or no difference in control developed with this material when a portion of the 325-mesh screen size was ground to a superfine stage because it was already in a superfine stage consisting largely of colloidal particles.

The most interesting and important conclusion to be obtained from this series of tests is that with every material certain trends previously observed seemed to be conclusively demonstrated. If the particle size was too large or of clay fineness, the results were not as good as with 325-mesh screen sizes. Earlier tests had indicated that some materials passing through a 300-mesh screen and held on 325 was better than most samples passing a 325-mesh screen. But this depends on the hardness of the material and the degree to which adhering clay-like particles are produced.

Experiment 5.—The purpose of this test was to determine if iron in the form of Fe_2O_3 had any deteriorating effect on rotenone in insecticidal dusts. A sample of Fe_2O_3 was mixed with *Pyrax* and used to disperse 0.1 per cent rotenone as it was believed that deterioration effects could be more easily detected than if higher concentrations of rotenone were used. The first series of tests were replicated three times in the spring of 1942, and the second with a similar number of replicates in 1944. The data is given in table 5.

RESULTS.—Low control with these dusts is attributed to the presence of colloidal particles in the Fe_2O_3. The average

particle size of the Fe_2O_3 was less than 1 micron and on a projected area basis it was calculated that each particle of rotenone would be covered with more than 100 layers of the dispersant. Differences in control between the two years may be attributed to the amount of dust used per test, 100 mgm. in 1942 and 200 mgm. in 1944. The test data indicate that as much as 10 per cent F_2O_3 in the dusts tested does not have any specific chemical deteriorating effect on as little as 0.1 per cent rotenone, but that, like any colloid, it physically impeded contact between the rotenone and insect.

Table 5.—The effect of iron (Fe_2O_3) on the toxicity of rotenone in insecticidal dusts.

Material	Per Cent Rotenone	Per Cent Oil	Per Cent Control 1942	Per Cent Control 1944
Pyrax+5% Fe_2O_3	0.1	2	37	53
Pyrax+5% Fe_2O_3	0.1	0	22	36
Pyrax+2% Fe_2O_3	0.1	2	37	56
Pyrax+10% Fe_2O_3	0.1	2	34	52
Pyrax, iron free	0.1	2	82	80

CONCLUSIONS.—The presence of small particles, particularly in the colloidal size range, has a hindering effect on the toxic values of rotenone dusts. When the average particle size of a dispersant is too large (60-mesh) the toxic efficiency of rotenone dusts is less than with intermediate size particles (200 to 325 mesh). If the majority of the particles are very small (1 to 10 microns), the efficiency is greatly reduced. Colloidal particles found in many dispersants tend to cover the cubé and derris particles so they cannot come in contact with an insect.

The main sources of colloidal particles in dispersants are free ferrous and ferric oxide, and chloritoid minerals (especially those high in ferrous iron) which are easily fractured to small particle size.

Pure quartz has been found to be the best available dispersant for rotenone but is undesirable because of its high abrasive qualities.

Pyrax (pyrophyllite, quartz, and mica) has been found to be an excellent dispersant, because being comparatively free of either ferrous or ferric iron, few colloidal particles are present. This material is high in quartz which also gives it the properties of quartz, but with less abrasiveness which occurs at the cleavage planes, than pure quartz because of the lubricating properties of the pyrophyllite cleavage planes.

Talc is a good dispersant when few colloidal particles are present, but if ferrous or ferric iron is present in a marked degree, colloidal particles are usually present in sufficient amounts to effect the efficiency of rotenone dusts.

Iron, either in the ferrous or ferric state, does not cause direct deleterious chemical effect on rotenone.—3-10-46.

AMBUSH BUGS KILLING BEES

On June 27, 1946, a correspondent from Doddridge County, W. Va. reported the finding of many dead bees on sweet clover, the bees having been killed by some other insect.

A request for specimens brought the common ambush bug, *Phymata wolfii*, with the further statement that the insect was present in hundreds and that often three or four were observed attacking a single bee. He further reports killing hundreds of the bugs on a single small bunch of sweet clover, and some others on other honey plants.

The reporter, Mr. J. O. Blake, is apparently a beekeeper and considers the bugs to be a major enemy to the bees.

CORRECTION

"DDT and Its Effect on Fish and Wildlife" by Clarence Cottam and Elmer Higgins of the Fish and Wildlife Service.

JOURNAL OF ECONOMIC ENTOMOLOGY 39 (1): 44-52.

It should be noted that in the section entitled Recommendations, an error has occurred in the second paragraph (page 52). Recommendation 2, *Always Use Minimum Necessary Dosage* should read:

Use less than 0.2 pound of DDT an acre in an oil solution to avoid damage to fishes, crabs, or crayfish; less than 2 pounds an acre to avoid damage to birds, amphibians, and mammals in forest areas. Do not use emulsions.

Control of the Sex Ratio in *Macrocentrus ancylivorus*

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One of the major problems in the mass breeding of *Macrocentrus ancylivorus* Rowher has beeu the regulation of sex ratio. Haeussler (1932), and Holloway (1934), found that the average sex ratio of *M. ancylivorus* in the field ranges from 53 to 60 per cent females, and Allen *et al.* (1940) obtained ratios as high as 70 per cent females from isolated lots of field-collected host material. On the other hand, Garman & Brigham (1933), report the ratios of females in the insectary decreasing from 50 to 25 per cent during the summer. Flanders (1945) obtained ratios as low as 9 per cent females in the insectary. Flanders also reports that excessive activity by the male caused by excessive heat, light, and parasite density is correlated with increases in the proportion of male progeny.

The sex ratio of *Macrocentrus ancylivorus* in the University of California Beneficial Insect Division's insectary at Albany has never consistently equaled the ratios found in the field. During August, when the largest percentage of males of the season appeared, reduction of light intensity and collection of females up to 24 hours old immediately resulted in a larger percentage of female progeny. The methods and the results of the regulation of the insectary conditions are reported here.

MATING ROOM TECHNIQUE.—The original mating room had a cloth collecting screen which formed a false wall in front of a west window. There was an 18-inch corridor between the screen and the window. The light on the screen and in the room depended on the weather.

Later, light intensity in the room was regulated by covering the window with *Masonite*. Some light was reflected into the room from around the edges of the Masonite which was set nearly an inch beyond the molding around the window. Two 18-inch square windows, 36 inches apart and 54 inches from the floor, were cut in the *Masonite* and could be closed or opened by sliding covers. The top third of the collecting screen also was covered to further reduce light intensity. There were 36 square feet of collecting screen in each room.

Since 24 hours are required for a single lot of females to become properly mated, two mating rooms are needed. These were formed by dividing the original mating room into halves with a solid wall containing a door. The corridor in front of the window remained undivided.

The routine for controlling sex ratio was to use the two rooms for collecting and for emergence and mating on alternate days. At 9 A.M. each day the parasite cocoons are moved from Room 1 to Room 2 (or from Room 2 to Room 1) where the parasites emerge over a period of 24 hours and mate in light of low intensity for 24 hours. Each day the window, situated before Room 1 (or Room 2), is opened at 9 A.M.; those parasites, which had emerged and mated the previous 24 hours and are on the walls and ceiling of the room, move toward the lighted screen where they are easily collected. When the inoculum needed for the day is collected by means of an aspirator, the remaining parasites, which are predominantly males, are eliminated by means of a vacuum cleaner. Room 1 (or Room 2) remains empty until 9 A.M. the next day when it again becomes an emergence and mating room and Room 2 (or Room 1) a collecting room.

The parasites in the mating room emerged from the cocoons which had been freed from the host cocoons for 1 to 10 days (Martin and Finney 1946). The cocoons of equal age were kept in separate trays in a rack. Each morning the tray containing the oldest cocoons was removed and replaced with a tray containing a new lot of cocoons. The maintenance of a 10-day turnover of cocoons kept the mite *Pediculoides ventricosus* Newp. under control.

Female parasites often appeared in the mating rooms with bent ovipositors. This condition was attributed to the cocoon remaining attached to the female for a time after her emergence for such individuals disappeared when the females were forced to crawl through a loose layer of excelsior placed over the cocoons.

SEX RATIO DATA.—The records for the sex ratio of *Macrocentrus ancylivorus* obtained in the mating room with three intensities of light and with different population densities are shown in table 1. The

daily temperature for each light intensity averaged approximately 78° F. with a range of 74° F. to 88° F.

Sex ratios were ascertained by taking a sample of 100 cocoons from each day's production in the insectary and holding them for emergence records. Since the records are averaged for biweekly periods or for the month, they are adequate for the measurement of trends. However, a single lot of 100 cocoons was found to give only a rough estimate of the sex ratio for one day because of an approximately ±9 per cent range from the average for other samples from the same day's production.

SEASONAL CHANGES IN SEX RATIOS.—

Table 1.—Effect of light intensity and population density on the sex ratio of *Macrocentrus ancylivorus*.

Month	Total Number Observations per Month	Total Parasites per Month		Per Cent Females			Ave. Parasites per Sq. Ft. of Wall & Ceiling Per Day
		Females	Males	Average	Minimum	Maximum	
Uncovered window—High light intensity 516 sq. ft. of wall and ceiling							
April 9–30	21	509	806	38	29	50	38
May 1–31	31	771	1173	40	21	59	46
June 1–30	28	868	1180	42	32	55	38
July 1–31	26	746	1405	35	24	45	40
Aug. 1–16	16	655	1309	33	13	54	52
Covered window—Reduced light intensity 348 sq. ft. of wall and ceiling							
Aug. 17–31	14	466	624	43	33	53	84
Nov. 1–30	30	1052	1384	43	28	55	9
Covered window—Lowest light intensity[1] 348 sq. ft. of wall and ceiling							
Sept. 1–30	28	1238	1139	52	39	75	92
Dec. 14–26	15	568	506	52	44	65	9
Jan. 1–12	12	475	431	52	37	62	9

[1] Light so dim that photographic light meter scarcely registered.

LIGHT INTENSITY.—The proportion of female to male parasites increased as light intensity within the mating room was decreased, table 1. The brightest intensity was correlated with the lowest percentage of females in July and August. When the light intensity was first reduced, the average percentage of females increased 10 per cent. A second reduction of light intensity to a point where a photographic light meter scarcely registered, caused an additional 9 per cent increase in the proportion of females, which gave a total increase of 19 per cent from the brightest to the lowest intensity.

In the presence of bright sunlight in the mating room, and independent of population density, the parasites were in a constant state of motion accompanied by promiscuous mating. In subdued light the activity of both sexes was much reduced. The males were no longer promiscuous as they were prone to be in bright light. As a result the females had more opportunity to become impregnated so that promiscuousness with the males was reduced. Mating pairs, or males trying to mate with one another, were not observed at the lowest light intensities, although there was mating, for otherwise the progeny would have been males.

There were seasonal changes in sex ratio when the light intensity inside the mating room was dependent on weather. The proportion of females decreased 7 per cent from May and June to July and August (Table 1) because the outside light was more intense during the latter months and also because the sun shone more directly into the room in July and August.

TEMPERATURE.—The April sex ratio average was influenced by temperatures dropping as low as 55° F. in the mating room; this inhibited mating. Unmated females, and most overmated females, of *Macrocentrus ancylivorus* produce only male progeny.

The highest proportion of females for

the season was 75 per cent. These were the progeny of females mated during the highest temperatures of the season in September when the average was 83° F. and the maximum 88° F. The higher temperatures may have reduced the time for impregnation and thus more females became fully impregnated within the time allowed for mating because the sperm could be transferred more rapidly from the spermatophore to the spermathecal sac.

POPULATION DENSITY.—The correlation of population density of *Macrocentrus ancylivorus* to sex ratio may be related both to the actual density of the insects and to the ratio of the sexes per density level. Flanders (1945) has reported conditions where certain ratios of sexes at some extreme levels of density do affect the sex ratio of the progeny of the females mated under the conditions he described.

Within the levels of population density used under the conditions of the mating room (Table 1) there was no relationship between sex ratio of the progeny and the average number of parent parasites per square foot of wall and ceiling. At the reduced light intensity used in August, the population was 9 times greater than it was at the same intensity in November, yet the sex ratios were the same. The data obtained at the lowest light intensity in September and December show the same sex ratio for high and low level populations.

The ratio of males, within the population densities used under the conditions of the mating room, did not have a relationship to sex ratio when light intensities were low. In August, the population on the screen was 67 per cent males, yet, in spite of the predominance of males, the sex ratio did change when the light intensity was decreased.

MATING PERIOD.—Apparently 24 hours was sufficient time for the females emerging within this period to become properly impregnated, since there was no change in the sex ratio when the period for holding *Macrocentrus ancylivorus* in the mating room was increased from 24 to 28 hours for the period January 1–12, table 1.

SUPERPARASITISM.—Flanders (1945) postulated that increases in the proportion of *Macrocentrus ancylivorus* males was correlated with superparasitism by unimpregnated females. When sex ratio data is obtained of parasites emerging from hosts superparasitized by lots of females which were assumed to be impregnated, it is apparent that it is the proportion of females that increases. The data are from two experimental lots where the degree of superparasitism was changed from one lot to another by varying the inoculum time and the number of female parasites, and a third lot consisted of samples from larval populations known to be lightly and heavily superparasitized. Parasite head capsule counts were used to verify differences in the degree of superparasitism. The data are presented in table 2.

Table 2.—Effect of superparasitism by supposedly impregnated females on sex ratio of *Macrocentrus ancylivorus*.

Date of Counts	Number Female Parasites Introduced	Inoculation Time	Number of Parasite Progeny		Per Cent Females
			Females	Males	
July 17	100	1 day	118	375	24
	100	5 days	123	276	30
	400	5 days	46	48	49
Sept. 4	100	3 days	28	37	43
	400	3 days	237	145	62
July 15	Lightlysuperparasitized		23	62	27
	Heavilysuperparasitized		210	190	47

SUMMARY.—The technique of handling *Macrocentrus ancylivorus* in the mating room to increase the proportion of females is described. The proportion of females was increased 19 per cent by decreasing the light intensity of the mating room, so as to reduce activity and promiscuous mating, and by allowing a 24-hour emergence period. Population density within the levels described did not influence sex ratio at the lower light intensities. Superparasitism by supposedly impregnated females increased the proportion of females.—2-9-46.

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The Control of Spittle Insects in Strawberry Plantings[1]

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While spittle insects are pests of major importance in tropical and subtropical climates, especially in the culture of sugarcane, they have not been regarded as particularly troublesome on agricultural crops in temperate zones until within the last decade. Under New York conditions the Cercopidae have a wide variety of host plants ranging from grasses to conifers and, so far as can be determined, they have few natural enemies. The economic forms are represented by only a few species; one of these, *Philaenus leucopthalmus* L., is often destructive to strawberries though it breeds abundantly on innumerable host plants. The species is composed of about eight varieties which resemble one another quite closely except for the coloration of the wing covers. This varies from a uniform brown or dull white to nearly all black. Perhaps the most common color combination is light brown with white and brown markings, though many specimens captured had a mixture of gray, black and white on the outer wings.

Injury to strawberries results mostly from the feeding of the nymphs. All parts of the plants are attacked including the crown, leaves, stems and fruit (Fig. 1). Heavy feeding in the region of the crown has a devitalizing effect on the plant, attacks on the stems distorts and sometimes kills them. The leaves when fed upon are stunted, the injured areas becoming crinkled and deformed (Fig. 2), and the extraction of juice from the berries makes them seedy and often misshapen. In certain regions of the country where infestations were heavy the estimated losses due to spittle bug feeding varied from a half ton to a ton per acre. Besides these definite injuries the froth frequently becomes a nuisance since it is

FIG. 1.—Strawberry plants showing the results of feeding by spittle insects. Plant on left was caged with about 200 nymphs. That on the right was protected from insect feeding.

often produced in such large quantities that portions of it separate from the original mass and drop to the fruit below giving it a shiny, unnatural appearance. Hidden among the foliage it is an annoyance to pickers who can scarcely avoid getting the hands or clothing daubed with it. According to Manns (1939) and Putnam (1940) this species may transmit

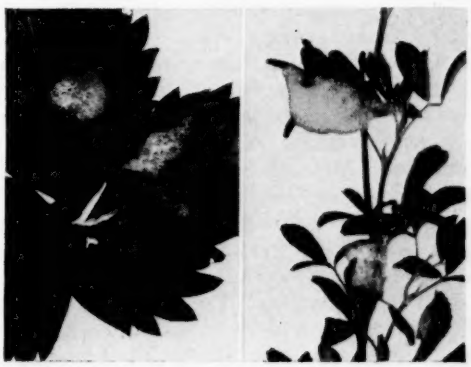

FIG. 2.—(Left) Underside of leaf showing froth masses and the type of injury resulting from nymphal feeding. (Right) Portion of alfalfa plant showing masses of spittle.

[1] Journal Paper No. 668, New York State Agricultural Experiment Station, Geneva, New York. (Feb. 21, 1946).

peach yellows and "little peach" and may be a carrier of the plum mite. Adults caged on some nursery stock retarded growth as much as 8 inches in 2 months.

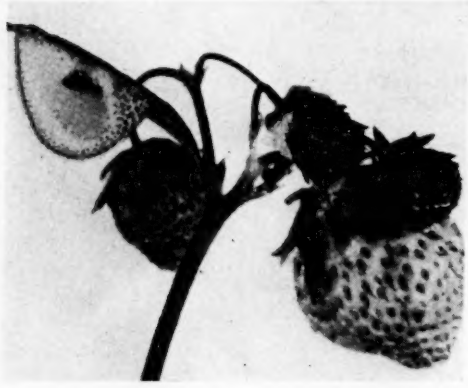

FIG. 3.—Portion of strawberry plant with froth mass containing recently matured hopper which can be seen in hollowed central area.

The present study was undertaken in response to demands for specific information on the life-history and control of these insects. Observations of caged specimens and of insects in the field showed that the nymphs hatched from over-wintering eggs, the first individuals appearing during April. Hatching continues usually through the month of May and the young nymphs require from 4 to 7 weeks to reach maturity. The first instar nymphs are yellowish in appearance and as a rule are plainly visible through the globule of clear liquid surrounding them, but nymphs of the older instars quickly conceal themselves within the froth masses (Fig. 3). Measurements of specimens indicate that there are five instars, the transition to the adult stage taking place early in July for the nymphs first hatched. Figure 4 shows a newly transformed adult about to leave the froth mass.

Oviposition begins in July but according to observations made in these studies it is most intensive in September and October. Females captured in September laid eggs in masses of one to 30 averaging six per mass and the number of eggs per female varied from 18 to 51. The egg is about 1 mm. long, yellowish in color, broadly rounded at one end and narrower and more or less pointed at the other. The egg mass is commonly placed in the axil between leaf and stem and the leaf securely cemented down over it (Fig. 4). The eggs lie parallel to one another in the mass but at a slight angle with the stem or leaf. Each mass is covered by a substance which is hard, glossy and brownish in color except at the exposed edges which are white and foamy in appearance (Fig. 4 inset). While eggs may be deposited on the upper portions of plants they are most commonly laid on the parts nearest the ground. Adults ordinarily can be found on vegetation until freezing weather in the fall during which season most of them perish.

The common term "spittle insect" applies very well to *Philaenus leucopthalmus* because of the large amount of froth produced by the nymphs. However, the adults also were observed expelling quantities of liquid while feeding. This process is unique in that the fluid is released spasmodically and with such force that it is projected through space for a distance

FIG. 4.—Lower portion of grass plant showing the location of spittle insect eggs, indentified by the white masses of the protective covering material protruding from between the blades of grass. Inset shows a mass of eggs. ×5.

many times the length of the insect, a faint cracking sound accompanying each ejection. On the foliage this liquid may be mistaken for dew. Many theories have been advanced to explain the origin and formation of froth by the nymphs. The

most recent studies by Doering (1922) and Cecil (1930) indicate that it consists of excreted liquid mixed with air or with gases given off during respiration.

Control tests were carried on in both alfalfa and strawberry plantings. The former served as an excellent test crop because of the abundance of spittle insects usually present and also because the foliage offers problems similar to that of strawberries. Further, alfalfa plantings can be easily treated by power equipment and relatively large plats can be used.

TESTS IN ALFALFA IN 1939.—The first treatments for the control of spittle insects during these studies were made in 1939 in an alfalfa planting. Two long, parallel strips each about 20 feet wide were divided into plats of about 400 square feet. On May 17th sprays were applied in two of the plats with power equipment; the dusts, however, were put on by hand, the materials for each test being weighed to determine the dosage per acre. Two untreated areas were left at each end of the treated strips. The air was warm and comparatively still during the applications. The efficiencies of the materials were determined by counting the number of live nymphs remaining on 1 square foot of each treated plat about 2 days after the applications, and comparing these data with those obtained from an equal area of the nearest check. Only portions of the plats which appeared to be of uniform foliage density were selected for the counts and all the live spittle insects on each alfalfa plant were recorded.

A study of table 1 shows that all of the rotenone dusts and sprays gave very high reductions in spittle insect population, and that a 1 per cent rotenone dust applied at the rate of 50 pounds per acre was very effective. Hydrated lime used at the rate of at least 500 lbs. per acre gave a satisfactory reduction in spittle insects. Nicotine dusts and sprays were not very promising except for tobacco dust containing 1 per cent nicotine which, at the rate of 500 lbs. per acre, showed fairly good results. Neither pyrethrum, calcium arsenate nor plain talc dusts were promising control materials as used. The

Table 1.—Results of treatments in alfalfa 1939.

PLAT NO.	MATERIAL	GALLONS OR POUNDS PER ACRE	NO. LIVE INSECTS PER SQ. FT.	PERCENTAGE REDUCTION
	Sprays			
16.	Ground derris root, 4 lbs., skimmilk powder, 8 oz., water 100 gals.	300	0	100
15.	Nicotine sulfate 1 qt., soap 3 lbs. water 100 gals.	300	108	64.9
	Dusts			
6.	1 per cent rotenone dust[1]	200	0	100
5.	1 per cent rotenone dust	50	14	96.6
8.	*Agicide* (.12% rotenone)	200	0	100
7.	*Agicide* (.12% rotenone)	50	6	93.3
10.	*Actirote* (1% rotenone)	200	0	100
9.	*Actirote* (1% rotenone)	50	4	95.5
14.	Hydrated lime	1000	14	95.5
13.	Hydrated lime	500	30	90.3
20.	Tobacco dust 1% nicotine	500	7.5	93.5
19.	Tobacco dust 1% nicotine	250	24	79.1
3.	Lime-nicotine 4%	50	118	71
4.	Lime-nicotine 4%	200	153	62.4
17.	Pyrethrum 15 lbs., Talc 10 lbs.	50	45	60.8
18.	Pyrethrum 15 lbs., Talc 10 lbs.	100	73	36.5
11.	Calcium arsenate-lime 25–75 lbs.	50	42	53.1
12.	Calcium arsenate-lime 25–75 lbs.	200	29	67.6
1.	Talc	500	133	67.3
2.	Talc	1000	129	68.3
	North-west check		407	
	South-west check		308	
	North-east check		89.5	
	South-east check		115	

[1] Talc was the diluent for rotenone in plats 5 and 6.

timing of the treatments was apparently optimum for good control.

TESTS IN STRAWBERRIES IN 1940.—In 1940 a strawberry planting was divided into 16 plats of about 0.05 acre each and treated on June 14th with various spray and dust materials, some of which are shown in the table. Untreated areas were left on three sides of the planting. The air was moderately warm and conditions generally favorable for the tests. The dusts were applied by hand but the sprays were put on with power equipment and all materials used were carefully measured to determine the dosage per acre. The comparative numbers of live spittle insects remaining in each plat after treatment were found by counting all those insects on four plants in the center of the plat. The check area nearest each treated plat was used in calculating the percentage reduction for the plat. The results of only the more promising rotenone and nicotine mixtures are shown in table 2, and it will be noted that rotenone in both dust and spray form gave substantial reductions in the spittle insect population. Neither the nicotine treatment nor commercial mixtures of pyrethrum or rotenone was effective as used. It is believed, however, that the timing of the treatments was probably a little too late to show the highest efficiencies of the materials and that under optimum conditions all treatments would have given still better results.

TESTS IN ALFALFA IN 1944.—In 1944, tests were made in a heavily infested alfalfa planting. Twenty-one plats each 22 feet wide and about a half acre in area were laid out across the planting and numbered consecutively from south to north. Plats 3, 10, 14 and 21, each equal in size to any treated plat, were left as checks. The alfalfa plants were about 30 inches high and the foliage was dry. Dusts were applied on May 31st with a *Bean* power duster mounted on a truck to which a 100 foot *Holes* cloth trailer was attached (Fig. 5). The truck was driven at the rate of about 1 mile per hour and dusting conditions were good, the temperature rising from about 70° to 75° F. during the experimental period. The comparative number of live spittle insects remaining in each plat after treatment was found by counting the number of such insects captured in 10 sweeps of a net in each of three areas, east, west, and center of each plat. The percentage reductions were determined by comparing the numbers of live spittle insects in each treated plat with the average number of the insects in the two nearest check plats, except in the cases of plats 1 and 2 which were nearest check 3 and were compared with it. The results of the treatments are shown in table 3. Rotenone 1 per cent with an oil conditioner[1] gave the highest reduction of all the materials used but a 0.5 per cent rotenone dust with an oil[2]

FIG. 5.—Power duster and trailer as used in treating alfalfa.

Table 2.—Results of tests in strawberries in 1940.

MATERIALS	DOSAGE PER ACRE	INSECTS PER PLANT	PERCENTAGE REDUCTION
West check		67.3	
	Sprays		
Ground derris root 5% rotenone 5 lbs., skimmilk powder 8 oz., water 100 gallons	300 gallons	8.25	87.7
Hydrated lime 10 lbs., nicotine sulfate 1 qt., water 100 gallons	300 gallons	23.3	65.4
	Dusts		
1 per cent rotenone	100 lbs.	1.3	97.3
	50 lbs.	11.5	75.2
	10 lbs.	14	69.8
East check		46.3	
West check		67.3	

[1] *Prorex D.*
[2] *Shell.*

Table 3.—Results of Tests in Alfalfa in 1944.

PLAT NO.	MATERIALS USED	SUPPLEMENT	POUNDS PER ACRE	NO. OF LIVE INSECTS IN 10 SWEEPS OF THE NET	PERCENTAGE
2.	Rotenone 1%	oil[4] 2%	48	7.3	95.3
5.	Rotenone 0.5%	oil[4] 2%	50	36.3	79.3
4.	Rotenone 0.5%	oil[4] 2%	44	48.0	72.6
11.	Rotenone (Special)[1] 0.4%	—	64	93.3	56.3
12.	Rotenone *Lethane Special* 0.4%	—	48	125.7	41.1
13.	Rotenone 0.4%	oil[5] 2%	48	95.0	55.5
6.	0.25%	oil[4] 2%	50	77.0	56.1
7.	Rotenone 0.1%	oil[4] 2%	54	113.0	35.6
8.	Rotenone 1%[2]	—	54	154.3	12.1
9.	*Lethane B 71* 2%	—	66	116.3	33.7
15.	*Lethane Special* 2%	—	40	105.7	35.4
18.	*DN* (Special)	—	34	125.7	23.2
19.	*DN* (Special)	—	54	68.7	58.0
17.	DDT 3%[3]	—	50	87.0	46.8
20.	Lime Nicotone 4%	—	68	63.3	61.3
1.	Hydrated lime	—	200	86.7	44.7
3.	Check	—	—	156.7	—
10.	Check	—	—	194.3	—
14.	Check	—	—	323 3	—
21.	Check	—	—	95.0	—

[1] "Special" denotes test mixtures not prepared at the station.
[2] *Agicides.*
[3] *Gesarol.*
[4] *Prorex D.*
[5] *Shell.*

conditioner also gave a very satisfactory reduction. A rotenone dust of the same concentration but with an oil was less effective. Dilutions of rotenone below 0.5 per cent gave reductions too low and therefore do not appear promising. Neither *Lethane, DN* compounds nor nicotine in dusts was effective as used. As in the previous experiment it is possible that the timing of the treatments might have been a little too late for the best control and as a result the true efficiencies of the various mixtures are probably greater than shown in the table.

TESTS IN ALFALFA IN 1945.—During this year tests were made in both alfalfa and strawberries. The alfalfa planting was divided into 23 plats similar to those used in spittle insect control studies of the previous season. Plats 1, 6, 11, 16 and 21 each representing approximately 0.5 acre and equal in area to the dusted plats were left as checks. The same Bean duster mounted on a truck was used for making the applications and the alfalfa at that time stood about 18 inches high. The first dusting was done on May 22 and weather conditions at the start were good but rain began to fall as the third plat was being treated. On May 25 dusting was continued. Weather conditions were good, with temperatures ranging between 60° and 75° F. and the lower portion of the plants were wet with dew. The truck carrying the duster and 60 ft. cloth trailer was driven at the rate of 2 miles per hour during the operation. The comparative numbers of live spittle insects remaining after the dustings were determined by sweeping with a net exactly as in the 1944 tests. However, two series of sweepings were made, one on the 7th and one on the 12th of June. The per cent reduction for any one treatment was calculated from the averages of the two nearest check areas except for plats 22 and 23 which were nearest plat 21 and were compared with it. The reductions shown in the table are averages for the two collections. A study of table 4 shows that all dusts with at least 0.5 per cent rotenone content and an oil conditioner were fairly effective against the spittle insects. Dust containing 1 per cent rotenone and an oil gave a very high reduction even when used at less than 50 pounds per acre. The 5 per cent DDT dust with an oil conditioner was about equal in effectiveness to the 0.5 per cent rotenone dust. A 3 per cent DDT dust when used with nicotine was slightly less effective than the same concentration of DDT applied with an oil conditioner. A 1 per cent DDT dust with an oil conditioner gave a very high reduction.

Table 4.—Results of tests in alfalfa in 1945.

Plat No.	Materials Used	Supplement	Pounds per Acre	Av. No. Live Insects Taken in Ten Sweeps of Net	Per centage Reduction
23.	Rotenone .75%	Nicotone 1.5%	48	21.4	95.9
17.	Rotenone 1%	Oil 2%[1]	47	33.2	93.9
18.	Rotenone .5%	Oil 2%	60	65.0	88.1
19.	Rotenone .25%	Oil 2%	58	178.7	67.2
20.	Rotenone .25%	*Velsicol AR 60* 2%	46	215.3	60.9
22.	Rotenone .25%	*Lethane 60* 2%	46	260.2	60.7
15.	D.D.T. 5%	Oil 2%	43	62.9	87.5
8.	D.D.T. 3%	Oil 2%	42	123.3	78.7
7.	D.D.T. 3% (Special)[2]	Nicotine .5%	48	160.4	74.3
12.	D.D.T. 1% (Special)	*Velsicol AR 60* 2%	40	140.7	80.7
9.	D.D.T. 1%	Oil 2%	36	335.7	41.0
10.	D.D.T. 1%	—	46	263.7	52.0
2.	Hydrated lime	—	400	173.2	68.6
3.	Nicotine (free) 4%	—	76	368.4	32.9
4.	*Lethane B 71*	—	52	403.2	14.2
13.	*Ryanex* 50%	Oil 2%	34	282.7	46.3
1.	Check	—	—	404.0	
6.	Check	—	—	654.7	
11.	Check	—	—	475.3	
16.	Check	—	—	550.7	
21.	Check	—	—	513.4	

[1] Paraffine base lubricating oil S.A.E. 10.
[2] "Special" denotes test mixtures not prepared at the station.

Hydrated lime at the rate of 400 lbs. per acre was not sufficiently effective to be practicable though it gave a reduction approaching that of 3 per cent DDT with nicotine. Neither nicotine, *Lethane B 71* nor *Ryanex* dusts as used, showed promise of control. The timing this season was perhaps more nearly correct than in the 1944 tests but it is felt that the applications might have been delayed a little beyond the optimum time for the very best results.

Table 5.—Results of tests in strawberries in 1945.

Plat No.	Materials	Supplement	No. of Live Insects per Plant	Per-centage Reduction
12.	1% Rotenone	2% oil[1]	2	95.4
11.	.75% Rotenone (special)[2]	1.5% nicotine	2	95.4
9.	.5% Rotenone	2% oil	3	93.2
2.	.25% Rotenone	2% oil	8	71.8
13.	5% D.D.T.	2% oil	6	86.3
4.	3% D.D.T.	2% oil	16	43.7
3.	1% D.D.T.	2% *Velsicol AR 60* 2%	3	89.5
8.	4% Nicotine (80% free)	—	12	72.7
5.	Hydrated lime	—	41	00.0
North check			51	
Center check			36.7	
South check			20.0	

[1] Paraffine base lubricating oil S.A.E. 10.
[2] "Special" denotes text mixture not prepared at the station.

TESTS IN STRAWBERRIES IN 1945.—A number of plants in a strawberry planting lightly infested with spittle insects were selected for a series of small tests. In an endeavor to secure data under conditions of heavier infestation, these plants and all others near them were supplied with additional spittle insects transferred from alfalfa plants. A number of plants at either end of the plat and two plants in the center were left as checks, and the treated plants were separated from each other by buffer plants. On June 9, after the insects had settled down, the various materials shown in the table were applied by hand, the dosage per acre probably averaging between 50 and 60 pounds. The temperature was high and the air was relatively still during the tests. Two days later, counts were made of all the live spittle insects on all plants in the experimental area. A study of table 5 shows that rotenone dust at 0.5 per cent concentration gave very satisfactory control. Mixtures containing 1 per cent rotenone dust with oil or 0.75 per cent rotenone with nicotine were very effective. The 0.25 per cent rotenone dust gave only a fair reduction approaching that with nicotine dust. DDT at 5 per cent concen-

tration and with an oil conditioner showed good results but the same material at 3 per cent concentration was not promising. A 1 per cent mixture with oil[1] gave results about equal to those secured with the same material in the tests of the preceeding experiment and while these may appear too high according to the efficiencies of other 1 per cent mixtures this particular dust appears to have merit and should be given further trials.

On June 18th mixtures of DDT and kerosene were applied at 4 and 8 gallons per acre respectively by means of a smoke generator. Two days later, sweepings with a net were made at distances of 10, 50, 100, 150 and 200 feet from the point of release of the insecticides to determine the comparative numbers of live spittle insects remaining on the plants. The results were entirely negative, no appreciable reductions in either the nymphs or the adults were found even at a distance of 10 feet from the generator.

DISCUSSION OF RESULTS.—From these tests it appears that a 1 per cent rotenone dust with or without an oil conditioner and used at the rate of about 50 pounds per acre, or a spray consisting of 5 lbs. of dérris in 100 gallons of water with a spreader and applied at the rate of 300 gallons per acre, are equally effective against spittle insects attacking strawberries and will give high reductions in the population of the insect. A 5 per cent DDT dust with an oil conditioner is also very effective and certain mixtures below this concentration may have definite promise as controls. Under optimum weather conditions and properly timed a 0.5 per cent rotenone dust with an oil conditioner applied at the rate of about 50 pounds per acre will give satisfactory control. Plain hydrated lime applied at 500 lbs. per acre under favorable conditions will give a considerable amount of protection against the insect. Most of the dusts containing nicotine sulfate were entirely ineffective. Dusts containing *Lethane, DN*, pyrethrum and plain talc were not promising as used. Rotenone therefore seems specific for this insect and has the added characteristic of leaving a very light and almost invisible deposit. The timing of the treatments is an important factor in control, the optimum period being the time after most of the eggs are hatched but before many of the nymphs have reached the fourth and fifth instars. According to the tests it appears that this will fall between the middle and the last of May, the most critical period in any season probably being nearer the fifteenth of the month than the thirty-first but the stage in development of the insect should determine this. In all cases the material should be applied with the aim of reaching all spittle masses on the plants.—1-14-46.

[1] *Velsicol.*

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MEN WANTED

The Office of Foreign Agricultural Relations, United States Department of Agriculture, is recruiting technically trained men in all branches of agriculture for Latin American service. Knowledge of Spanish is valuable, but not required. Veterans and former Federal employees will be given priority on all appointments. Anyone interested should write to Mr. C. E. Michelson, Chief, Division of Administration, Office of Foreign Agricultural Relations, United States Department of Agriculture, Washington 25, D. C.

Dusting Blueberries to Control the Cranberry Fruitworm[1]

B. B. FULTON,[2] *North Carolina Agricultural Experiment Station, Raleigh*

Three different species of insects have been found attacking the fruit of the cultivated highbush blueberry in North Carolina. The most destructive one is the cranberry fruitworm, *Mineola vaccinii* (Riley). The plum curculio, *Conotrachelus nenuphar* (Herbst), is second in importance although on one farm it has been more numerous than the cranberry fruitworm during some years. A third insect, a red lepidopterous larva, is of minor importance and has not yet been identified. The blueberry maggot, which is a serious pest in most of the northern states, does not occur in eastern North Carolina and for this reason no regular insect control program has been necessary and most blueberry farms do not have insecticide equipment.

The cranberry fruitworm has been slowly increasing in North Carolina for several years. In 1944 there was a decided increase and serious losses were incurred in the early crop on some farms. In 1945 the increase was even more widespread. The losses caused by the cranberry fruitworm and curculio are not so much due to the reduction of fruit as to the cost of sorting out wormy berries or to the lowering of the grade for part of the crop. The fruitworms pass from one berry to another, finally consuming several berries and webbing them together so that the withered berries in a cluster are picked with the good. For this reason, the fruitworm is more destructive than the curculio grub which destroys only one berry.

With the increase in cranberry fruitworms in 1944, several growers decided to attempt some control for this insect during the following year. Control of the insect on cranberry by a number of standard insecticide sprays has been reported by Franklin and Crowley in the annual reports of the Massachusetts and Washington experiment stations over a period of years. Much less work has been done with the insect on blueberry and very little with dusts on either crop. Franklin (1937) reported fair control with three applications of pyrethrum dust on cranberry. Bailey *et al.* (1941) state that the fruitworm can probably be controlled on blueberry with 2 per cent rotenone dust at 100 pounds per acre. Beckwith (1943) reported control on blueberry with two airplane applications of pyrethrum dust. Hutson (1944) found dusting from the ground with rotenone or pyrethrum ineffective on blueberry, but he got control by spraying with rotenone or fixed nicotine plus summer oil. In the spring of 1944, the writer obtained a marked reduction in the number of wormy berries in some small plots dusted with cryolite with a hand duster, even though many of the worms had entered the first berry before the dust was applied.

The boggy nature of the ground on most of the blueberry farms in North Carolina makes the use of heavy spraying equipment impractical following wet weather. No landing field for airplanes was near and no pyrethrum dust could be obtained. After due consideration, several growers acquired power dusters and it was decided to try cryolite dust in an early application and follow with 1 per cent rotenone dust for as many more applications as seemed necessary.

The seasonal history of the cranberry fruitworm was closely followed as a guide to timing the insecticide applications. On March 21, 1945, a number of cocoons were collected at Ivanhoe, North Carolina and taken to Raleigh for observation. At that time both larvae and pupae could be found in the cocoons. The cocoons are sand-covered silk capsules about 10 mm. long and 5 mm. wide. They are found just under the surface of the soil within a few inches of the trunk of the bush. The cocoons were placed in crocks of moist sand with screen covers. From one lot kept in a greenhouse, the first moths appeared on March 30, and from another lot in a screened house, the first moths appeared on April 3. Moths continued to emerge for about two weeks and the last one died some time after April 24.

Only one cranberry fruitworm moth was found in a blueberry field and that

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one was collected on April 5. Two recently cast pupal cases were found on the previous day. No cranberry fruitworm moths were caught in molasses bait cans hanging in the bushes during this period. The first egg was found on April 5. On April 12, just after the first dust was applied, a few berries were found containing small worms mostly in the first instar. At that time most of the berries were 5 to 8 mm. in diameter. In nearly every case the larva entered the berry at the junction of the stem and berry. The egg shells were found under the calyx lobes. An egg was found in the field on April 16 but none on the next visit to the field on April 26, when some larvae were found in the fifth (last) instar.

The first cocoon was formed on April 30 by a larva collected on April 16 and reared in the laboratory. By May 14 most of the worms in the field had left the berries. Due to an unusually warm March in 1945, the seasonal history of the insect was two or three weeks more advanced than in 1944 which was a more normal season.

The results of the dusting were checked by the writer on the Gale Harrison blueberry farm near Ivanhoe, North Carolina. The dusting machine used on this farm had an overhead boom carrying four outlets directed diagonally downward so as to cover both sides of two rows. Two low outlets directed dust upward from one side only into the same two rows. The machine was drawn by a light tractor and equipped with lights so it could be used at night to take advantage of the calm night air. On the night of April 11, 1945 nearly the whole farm was dusted with a mixture containing cryolite 70 per cent, sulphur 10 per cent, talc 20 per cent, at an estimated rate of twenty pounds per acre. A small portion was dusted with 3 per cent DDT. Due to a delay in delivery of the 1 per cent rotenone dust, it was applied only on the night of April 26 and then only to blocks of large bushes. The smaller bearing bushes, where the fruitworms had been most severe during the previous season, received only the one application of cryolite or DDT dust. Weather conditions were ideal during and following both applications. Precipitation records taken on the farm were as follows: April 17, 0.15 inches; April 20, 0.24; April 23, 0.53; April 25, 0.51; May 3, 0.64; May 17, 1.25.

The results of the dusting were taken on May 2 by picking off and counting all the withered berries on a number of the small bushes which were dusted only once. The total number of withered berries was divided by the number of bearing twigs. The undusted check was a row of seedlings of the same species of blueberry and of the same size as the small dusted bushes. The results are summarized in the table 1.

Table 1.—Control of cranberry fruitworm by DDT and cryolite dusts.

Dust	Variety	Number of Bushes Counted	Withered Berries Per Bearing Twig
3% DDT	Weymouth	10	.46
3% DDT	Rancocas	5	.54
70% cryolite	Weymouth	10	.42
70% cryolite	Rancocas	10	.42
Check	seedlings	20	3.23

The check had 6.5 times as many withered berries as the average of DDT plots and 7.7 times the number found in the cryolite plots. No counts were made on the large bushes which received 1 per cent rotenone in the second dusting on April 26. This dust apparently was applied too late to have much effect on the control. The proportion of infested berries did not appear to be much smaller than in the bushes dusted only once.

The withered berries included a considerable proportion injured by curculio and a very small proportion injured by the red larva, as well as dead berries due to all other causes. Of 137 withered berries from a cryolite dusted plot, the cause of injury was as follows: curculio 24 per cent, cranberry fruitworm 40 per cent, undetermined cause 36 per cent. The relative proportion of fruitworm larvae was much higher in the check, indicating that the differences between the check and the dusted plots were mainly due to control of this insect. Curculio eggs were found in berries a week before the first dust was applied showing that an earlier application would be needed for curculio control.

There was a slight amount of insecticide injury from the DDT and cryolite dusts. This appeared as a pinkish spot on the green berry. Some of the injured berries probably fell off and others grew and

ripened with a blemish on one side. At picking time, the number of such berries was so small that they were not considered objectionable in the pack.

Two other growers dusted with cryolite at about the same time. All were well pleased with the small amount of wormy berries in the crop as compared to previous years. The infestation on all dusted farms was so low that culling was unnecessary.

Following the dusting, an experiment was tried on another farm to see whether worms going into the soil to form cocoons could be poisoned by DDT. A spray of 200 grams of 20-per cent wettable powder in five liters of water was applied around the base of twenty undusted bushes and on another lot small handfuls of 3 per cent dust were thrown against the base from two directions. At the time of application, some larvae had reached the last instar but none had gone into the ground. In June, sand from under the treated bushes and from untreated checks was dried and sifted to obtain cocoons. The average number of cocoons per bush and the proportion of dead and living larvae was almost the same in the three plots.

In the laboratory, worms were allowed to cocoon in a crock of sand with 3 per cent DDT dust sprinkled over the surface. About a week after the last cocoon was formed, all (19) were sifted out and opened. No dead larvae were found. These results offer no promise of control along these lines. The hibernating larvae probably could be killed by a suitable soil fumigant, but the labor required by such a treatment is so great that it will not be considered as long as there is hope of control by other means.

The results of these experiments show that it is possible to control cranberry fruitworm by dusting with cryolite or DDT, but further experiments will be needed to prove whether other materials may be substituted or whether dusts will be effective under more normal and more adverse weather conditions.—3-11-46.

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U.S. NAVY COMMENDS BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE AND 32 BUREAU SCIENTISTS FOR WARTIME RESEARCH

The Journal of the American Medical Association, Volume 131, Part 2, page 145, 1946, carried the following item headed "Bureau of Agriculture Department Commended."

"The Bureau of Entomology and Plant Quarantine of the Department of Agriculture was recently commended by Secretary of the Navy James Forrestal and Vice Admiral Ross T. McIntire, Surgeon General of the Navy, for research conducted in the development of insect and mite repellents.

"In a letter to the Secretary of Agriculture, Secretary Forrestal stated that the Bureau of Entomology and Plant Quarantine 'rendered a fundamental and outstanding contribution to naval forces which has changed the entire methodology in the control of insect borne diseases.'

"Vice Admiral McIntire, in letters of commendation to Dr. P. N. Annand, Chief of the Bureau, and thirty-two of his associates, said that the immediate recognition of the great military potentialities of insecticides, such as DDT, aerosols, insect repellents and protective fabrics, resulted in their conversion to maximal efficiency for military use.

"The close cooperation and assistance rendered the Navy by the Bureau of Entomology and Plant Quarantine were in a large measure responsible for the successful development of the repellents which made it possible to carry on our military campaigns in tropical areas with a freedom from disease formerly thought impossible, the Surgeon General pointed out."

Sabadilla and DDT to Control the Hairy Chinch Bug

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In early May of 1945, the Entomology Department of the New Jersey Experiment Station was asked to determine the cause and suggest remedial measures for insect injury occurring to bent grass turf on the athletic fields at Rutgers University. Examination of the playing fields showed a fairly uniform infestation of overwintered nymphs and adults of the hairy chinch bug, *Blissus hirtus*, and extensive turf injury which was attributable to infestations of this insect in past years. A survey of the 80-acre athletic plant, disclosed that the chinch bug infestation covered an area of approximately 40 acres which was centered about the stadium football field. The density of chinch bug population ranged from 5 to 15 overwintered nymphs or adults per sqaure foot with the higher populations centered about the football stadium where sod and landscaped banks provided excellent winter hibernating quarters. As injury to the turf was extensive from previous infestations it was desirable to bring this outbreak of chinch bug under control during the 1945 season, if an expensive reseeding or resodding operation was to be avoided. The extent of the infested area, and the wartime restrictions and shortages of rotenone and nicotine prevented the procurement of sufficient quantities of these recommended insecticides to treat the infested area, and made it necessary to experiment with available materials to find a satisfactory insecticide for the control of this insect.

PLOT TESTS WITH OVERWINTERED BUGS.—As it was necessary to test a number of insecticides of unknown toxicity to the chinch bug, a series of small plot tests were carried out on one of the athletic playing fields. These tests were run in plots 4 by 4 feet with board barriers 5 inches high placed around each plot. To prevent the migration of the chinch bugs to and from the plots, the top inner surface of the board barrier was smeared with vasoline or cup grease, while sand was piled against the outer bottom surface of the barrier. The chinch bug population in the various plots was equalized by the collection and liberation of known numbers of chinch bugs before the test insecticides were applied to the turf. The efficiency of the tested insecticides was judged by the number of live chinch bugs found in the plots at various intervals after the treatments had been applied. Experience with check plots demonstrated that it was possible to recover from 85 to 90 per cent of the live chinch bugs liberated in a test plot when a casual search was made several days later. Attempts to recover a higher per cent of the liberated insects proved too time-consuming to be practical and where it was desirable to recover the dead insects it was found necessary to confine the liberated bugs to smaller cages within the treated plots. In general these plots proved very satisfactory for the preliminary testing of insecticides and could be kept under observation for several weeks if occasional attention was given to the maintenance of barriers.

These preliminary tests showed that two materials, sabadilla and DDT, exhibited considerable toxicity to chinch bugs. When inquiries concerning sources of supply indicated that these materials would be available in considerable volume testing operations were aimed at determining the concentration and rate of application that would be necessary for chinch bug control.

Rate-of-application tests with power dusters showed that complete and thorough coverage of turf could be obtained with dust applications of approximately 100 pounds per acre when trailer cloths were used to confine the dust. When hand equipment was used the dust applications were less uniform and a somewhat higher rate of application was necessary to obtain thorough coverage. Tests with dusting equipment at our disposal proved that this rate of application was practical and this dosage was used to determine the concentrations of sabadilla and DDT dusts necessary for chinch bug control. Experimental dusts were prepared from a 50 per cent DDT dust obtained from Sherwin-Williams Company, Bound Brook, N. J.

[1] Journal Series paper of the New Jersey Agricultural Experiment Station, Rutgers University, Department of Entomology.

and from 10 per cent and 50 per cent Sabadilla dusts obtained from McConnon and Company of Winona, Minnesota. DDT dusts of 1, 3, 5, 10 and 25 per cent, and sabadilla dusts of 2.5, 5 and 10 per cent concentrations were prepared from the stock material by using talc as a diluent. These dusts were applied with hand equipment and the test plots were observed daily for periods varying from 10 to 30 days.

RESULTS OF PLOT TESTS.—A series of small plot tests during May and June 1945 with sabadilla and DDT dusts seems to justify the following conclusions.

1. At concentrations of 10 per cent or above, both sabadilla and DDT dust gave practically 100 per cent control of chinch bugs. At dust concentrations below this level the effectiveness of both materials was reduced to an extent that these lower concentrations were not considered practical for control.

2. Observations showed that chinch bugs were stimulated to greater activity following dust applications of sabadilla and DDT but the stimulation effect of sabadilla was more pronounced and this action became greatly accelerated at higher temperatures. Stimulated activity must be considered a desirable trait of these materials as it caused the chinch bugs to receive a more thorough coating of the insecticide.

3. The speed of toxic action of sabadilla and DDT differed greatly when tested against the chinch bug. The toxic action of sabadilla was very rapid, with paralysis occurring a few hours after dust application and the death of the chinch bugs within 48 hours. The action of DDT was much slower with the chinch bugs remaining in a sluggish, torpid state for a period of 4 or 5 days before death occurred. Because of this slow toxic action, the effectiveness of DDT dusts cannot be evaluated for a period of at least 5 days following dust applications.

4. Small plot tests demonstrated that dusts containing concentrations of 10 per cent or more of DDT exhibited a residual toxic action to chinch bugs for periods of 10 to 14 days (following dust applications). The duration of the residual action in dust applications is influenced to a great extent by rainfall that occurs following the dust applications. Residual toxic action could not be demonstrated with sabadilla dusts or with DDT dusts containing concentrations of less than 10 per cent DDT. It was also demonstrated that under normal climatic conditions the residual toxic action of 10 per cent DDT dust applications was of sufficient duration to kill any nymphs which might hatch from eggs produced by adults that were present when the dust was applied.

LARGE PLOT TESTS IN 1945.—The favorable results obtained in our preliminary tests with sabadilla and DDT dusts warranted the testing of these materials on a larger scale. A chinch bug infestation on the turf plots at the New Jersey Experiment Station presented an opportunity to make some large scale comparative tests of sabadilla, DDT and rotenone dusts for the control of this insect. In this test, plots containing approximately 6000 square feet were treated with 1 per cent rotenone, 5 per cent DDT, 10 per cent DDT and 10 per cent sabadilla. Dusts were applied with a *Messinger* row duster which was modified so that the dust was delivered under a small hood equipped with a short trailer cloth. With this equipment a uniform and thorough coverage of the turf could be obtained with dust applications of 100 pounds of dust per acre. Chinch bug population counts were made by the hot water method described by McLeod & Maxwell (1937) before the dust applications were applied and 7 days following the application. The results of these tests are shown in table 1.

Table 1.—Chinch bug population counts, college farm turf plots, July 1945.

Materials Applied at Rate of 100 Lbs. per Acre	Number of Readings	Chinch Bugs per Square Foot		Per Cent Reduction 7 Days After Treatment
		Range	Average	
Before Treatment	16	313–18	134	—
Rotenone, 1%	6	57–9	38	73
Sabadilla, 10%	12	37–2	13	90
DDT, 5%	10	43–22	31	76
DDT, 10%	8	6–0	3.5	97

The results of this test confirm our preliminary findings concerning the high efficiency of 10 per cent DDT dust in controlling the hairy chinch bug. The performance of the 10 per cent sabadilla dust was not as effective as preliminary tests had indicated, and there seems to be a possibility that this lowered efficiency

might be due to migration of the surviving chinch bugs from other plots during the seven day interval that occurred following the dust applications. Such a migration would tend to lower the efficiency of the 10 per cent sabadilla treatment to a greater extent than the 10 per cent DDT treatment as sabadilla does not possess the residual toxic action exhibited by the 10 per cent DDT dust. Further evidence of migration was found in the 10 per cent DDT treatment where the few surviving insects were recovered from the edges of the plot while counts in the center of the plot failed to reveal any live chinch bugs. The 1 per cent rotenone and 5 per cent DDT dust treatments gave too low a reduction in population for these treatments to receive consideration as practical measures for chinch bug control.

As it was desirable to obtain additional information of the effectiveness of sabadilla, a series of plots containing approximately 1000 square feet were laid out on sections of the turf plots where we had failed to control the chinch bugs. Each treatment was replicated and population counts were made prior to and 5 days after the dust application. Dust treatments were made with a knapsack duster and applications of approximately 150 pounds of dust were necessary to obtain uniform and thorough coverage of the turf. Applications of sabadilla and sand were tested to provide an alternate method of application for the small home owner. The amount of sand used in these tests was determined by the rate of application of available equipment. In these tests 2.3 and 4.6 pounds of 10 per cent sabadilla dust and 42 pounds of sand were applied per 1000 square feet, this is equivalent to applications of 100 and 200 pounds of 10 per cent sabadilla dust per acre. The results of these tests are found in table 2.

Table 2.—Chinch bug population counts before and after treatment with 10 per cent sabadilla dusts applied with hand equipment.

Sabadilla Tests Hand Equipment	Lbs. per Acre	Population per Sq. Ft. Before Treatment	Population per Sq. Ft. After Treatment	Per Cent Reduction
Sabadilla Dust 5%	150	43	14	67
Sabadilla Dust 10%	150	75	6	92
Sabadilla 10%+Sand	100	46	9	81
Sabadilla 10%+Sand	200	61	6	90

In these tests the 5 per cent sabadilla and the sand and 10 per cent sabadilla at the rate of 100 pounds per acre gave too low a reduction in chinch bug populations for these treatments to be considered for practical chinch bug control. The 10 per cent sabadilla dust treatment and the sand and 10 per cent sabadilla at the rate of 200 pounds per acre gave reductions in chinch bug populations of 92 and 90 per cent respectively. While the 10 per cent sabadilla dust again failed to exhibit the high degree of effectiveness shown in the preliminary tests, this material has constantly shown sufficient toxicity to be considered as a practical treatment for chinch bug control. During the summer of 1945 sabadilla was the only insecticide readily available to the home owners and 10 per cent sabadilla applied at the rate of 100 pounds per acre was generally recommended for chinch bug control. Reports indicate that home owners found this treatment gave satisfactory control of chinch bugs during the 1945 season.

LARGE SCALE TESTS WITH DDT.—During the summer of 1945 the following large scale field tests with DDT were undertaken.

Rutgers University Athletic Fields.—The chinch bug infestation on the Rutgers Athletic fields covered an area of approximately 40 acres and was largely responsible for the initiation of our preliminary studies to find available insecticides to control this pest. As our studies indicated that 10 per cent DDT applications at the rate of 100 pounds per acre was the most promising treatment, arrangements were made for the release of sufficient DDT dust, so that the infested playing fields could be used as a large scale demonstration of the effectiveness of this treatment for chinch bug control. A 50 per cent DDT dust concentrate was obtained[1] and a 10 per cent DDT dust was prepared in a *Messinger* dust mixer by using talc as a diluent. The dust was applied at the rate of 100 pounds per acre with a 6-row potato duster which was equipped with a 30 foot trailer cloth to confine the dust. A tractor equipped with a power take-off provided power to run the duster and pull the equipment. The first dust applications were applied on June 29 and after a few trial runs to check the rate and thorough-

[1] From E. I. du Pont de Nemours Co., Wilmington, Delaware.

ness of application, from 2 to 3 acres were dusted per hour. Dusting operations were limited to periods of the day when the grass was dry, 10 A.M. to 7 P.M., to insure thorough penetration of the dust to the base of the plants where the chinch bugs were feeding. On several occasions dusting operations were stopped when the wind was strong enough to lift the trailer cloth. We found that the trailer cloth confined the dust to the treated area and the drag of the cloth displaced the dust from the upper surface of the grass and deposited it around the base of the plants where it would contact the feeding chinch bugs. Dusting operations on this 40 acre plot required approximately 20 hours time of the equipment and 2 operators and under existing weather conditions the operation could have been completed on June 29, 30 and July 1. Because of the press of other duties approximately a week was required to complete the dusting operation.

On June 29 when dusting operations were started the chinch bug population was determined by a series of counts in various parts of the infested fields. The hot water method was used to make these counts and an average population of 23 chinch bugs per squre foot was obtained. The counts showed that approximately 90 per cent of the chinch bugs were adults and 10 per cent 1st and 2nd instar nymphs which indicated that the dust treatment was being applied at the start of the 1st brood. After dust treatments were completed insect counts by the hot water method and extensive scouting of the border areas of the fields at intervals throughout the summer failed to reveal any live chinch bugs.

State House Grounds, Trenton.—In July of 1945 a severe chinch bug infestation on the bent grass lawns of the State House grounds in Trenton, was called to our attention. Inspection of the lawns revealed considerable injury to the turf and population counts by the hot water method showed an average chinch bug population of 117 per square foot. As the lawn area was adjacent to buildings and cut up into small areas, dusting operations did not seem feasible. A 300 gallon orchard sprayer was available so it was decided to test the efficiency of a DDT spray as a control for chinch bugs. Arrangements were made to treat this infestation on July 17, using a 50 per cent DDT wettable powder at the rate of 2 pounds per 100 gallons. Light showers occurred on the 17th but as the equipment and help was on hand it was decided to complete the operation. The spray was applied with a spray gun adjusted to give a cone shaped mist and care was taken to obtain thorough coverage of the lawn area. It was found that thorough coverage of an acre of lawn could be obtained with 600 to 800 gallons of spray, which was equivalent to 6 to 8 pounds of actual DDT per acre. Population counts made on July 24, 7 days after the spray application, showed an average of 6 chinch bugs per square foot, which represents a reduction in population of 96 per cent. The area covered by the first tankful of spray which was applied, when the agitator was not functioning properly, showed an average chinch bug population of 100 per square foot and it was necessary to retreat this area. The degree of control obtained in this test is considered excellent when one considers that over 5 inches of rain fell in the 7-day period following the spray applications. Inspections of this lawn later in the season showed that the chinch bug infestation was kept under control for the entire season by this one spray application.

Eastern Airways Plant, Linden.—In May 1945 a chinch bug outbreak on the lawns of the Eastern Airways Plant at Linden, N. J. was brought to our attention. The lawn area of 2 to 3 acres consisted of a dense mixed bent grass turf which was maintained at a cutting height of one and one-half inches. In past years this turf had suffered moderate to severe chinch bug injury and the recommended nicotine and rotenone treatments had failed to give satisfactory control. The proximity of office buildings made dust applications impractical, so plans were made to incorporate the DDT with a top dressing application which was applied annually to this lawn. The DDT used in this experiment was mixed with an organic top dressing and this mixture was applied with a fertilizer distributor at the rate of 700 pounds per acre.

This treatment was applied on July 12 at a time when the chinch bug population averaged 36 to the square foot. Counts by the hot water treatment made on July 27 showed an average chinch bug population of one per square foot

which represented a reduction in population of 97 per cent. As the entire lawn area at the Eastern Airways Plant was treated, the lawn area on an adjoining property was used as a check area. Population counts showed that the average chinch bug population increased from 36 to 41 per squaref oot in the period July 12 to July 27.

The lawn area at the Eastern Airways Plant was checked at frequent intervals throughout the season and we were unable to find any chinch bugs after July 27.

A check up of the amount of DDT[1] used in the top dressing in this test disclosed that DDT was applied at the rate of 40 pounds per acre. This high rate of application seems excessive in view of the fact that excellent cleanup of chinch bugs was obtained with 10 pounds of DDT per acre in other experiments. We must admit, however, that the dense high cut turf present in this test presented rather difficult conditions for chinch bug control. Observations indicate that a period of about 10 days was required for the top dressing to work down to the base of the plants and under these conditions the kill of chinch bugs was somewhat slow. The one application controlled the chinch bugs for the remainder of the year. It is the writer's opinion that future tests with top dressing will show that satisfactory control of chinch bugs can be obtained with smaller quantities of DDT.

Knoll Country Club Tests, Boonton, N. J.—In August of 1945 a request was received from the Knoll Country Club for assistance in controlling a chinch bug infestation on fairways and greens. A visit was made on August 17, 1945, which disclosed a general infestation and severe injury to the greens although these greens had received from 2 to 3 applications of 1 per cent rotenone dust during the summer. Arrangements were made to treat three greens with 10 per cent DDT so that a comparison of the rotenone and DDT treatments could be obtained. The following greens were treated on August 20 with 10 per cent DDT at the rate of 100 pounds per acre.[2]

	Area	*Chinch Bugs per Sq. Ft.*
Green #4	10,000 sq. ft.	40
Green #13	7,200 sq. ft.	65
Green #17	10,000 sq. ft.	95

Population counts made by the hot water method on August 20 at the time the greens were dusted and on August 27, one week later, disclosed that the chinch bug population had been eliminated on the DDT treated greens. Examination of greens treated with 1 per cent rotenone dust a few days prior to August 20 showed the chinch bugs to be rather numerous. The DDT treated greens were kept under observation until the latter part of September and up to this time no live chinch bugs were discovered.

CONCLUSIONS.—Tests undertaken in 1945 showed that 10 per cent sabadilla dust and 10 per cent DDT dusts applied at the rate of 100 pounds per acre gave better than 90 per cent reduction in chinch bug populations. DDT gave satisfactory control of chinch bugs when applied as a spray and when incorporated with top dressing applications.—2-23-46.

[1] Merck & Co., Rahway, N. J.

[2] Application made with a Pressure Turf Duster.

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The fourth edition of this widely used work has the same general outline as before, but there has been considerable revision and addition within each chapter. Mathematical relations are much more stressed than in former editions; and more complex aspects of sampling, and of approach to experimental design, are developed. The informal atmosphere, and the close relation to practical needs, are retained. The author and his associates continue their course of trying to make statistics serve experimental needs.

F. M. WADLEY.

The Control of Storage Insects in Corn Seed

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Under natural conditions in warm climates, cereal seeds soon become infested by storage insects and largely as a result quickly loose their viability. In Puerto Rico, corn, widely used for human food as well as stock feed, suffers the most, chiefly from the rice weevil *Sitophilus oryza* (L.). Sometimes the seed ears become infested in the field before harvest, and most certainly during the several weeks necessary for drying after harvest. If protection is not provided early, viability is so seriously affected by weevil attack that in a few months the grain becomes worthless for seed. Many methods of protection, such as fumigation and isolation in dry or cold storage, are not always available or practicable of timely application, especially by the small farmer. A simple treatment that could be safely applied soon after harvest and thus keep infestation from gaining headway during the drying period, as well as afford subsequent protection during storage, would prevent the serious infestation of many a seed supply. Even protection for 4 or 5 months would be advantageous, as in this time the seed would ordinarily be used and thereafter viability decreases rapidly from other causes. A series of experiments was carried out to test the effectiveness of certain treatments seeming to meet these requirements, with especial emphasis on those that could easily be adopted by the small to average farmer.

Copper carbonate in dust form as used for smut control, has been said to give absolute freedom from the rice weevil and other insects which attack stored grains, (Essig & Hoskins 1944, p. 159), and oils and oil emulsions have been used to protect corn (Flint & Mohr 1930). Dusts of silica, lime, magnesia, wood ashes, and clays have also been employed to protect these and various other seeds (Chiu 1939; Cotton 1943). More recently, certain organic compounds, as phenothiazine, phenoxathiin, and DDT, have been under experiment (Smith 1937, 1942; Frankenfeld & Cotton 1945). Of these, copper carbonate, on account of its ease of application and known fungicidal properties, appeared most likely to prove desirable, and phenothiazine and phenoxathiin, both toxic to many insects, also seemed worthy of trial. Each of the three chemicals was used alone and in combination with lime as a carrier, and lime alone was also tested. For comparison, carbon bisulfide fumigation was included in two of the tests and the usual control in all of the tests. While the *USDA-34* variety of sweet corn was employed throughout, the methods tested would be applicable to the seed of other varieties of corn and other cereals, and possibly to the seed of other farm crops.

Materials and Methods.—Each treatment was applied to the grain on 100 average seed ears (Figure 1, A) in 5 replicate lots of 20 ears each selected at random throughout the field. Drying, at an average temperature approximating 80° F. and an average relative humidity of about 70 per cent, was carried out in the manner usually employed by the small farmer; *i.e.*, the ears were husked as soon as harvested and hung up in an open shed to dry until the grains could be easily shelled, which was in about 1 month. All dust adhering to those ears that had been treated in the partly dry condition was allowed to mix with the seed as it was shelled. Individual cheesecloth sacks of about 2-quart capacity were used to hold the shelled seed, all replicates except those fumigated being randomized in open, dry storage where the rice weevil and other grain insects had easy access to them. Sampling for insect attack and viability was done at time of shelling and at frequent intervals up to 5 months thereafter, the grain in each replicate being thoroughly mixed each time. Approximately 50 grains of corn were drawn with a grain trier, introduced through the mouth of the sack, from opposite sides and the middle of each sack. From this combined quantity, 100 grains were taken at random as the sample of that replicate.

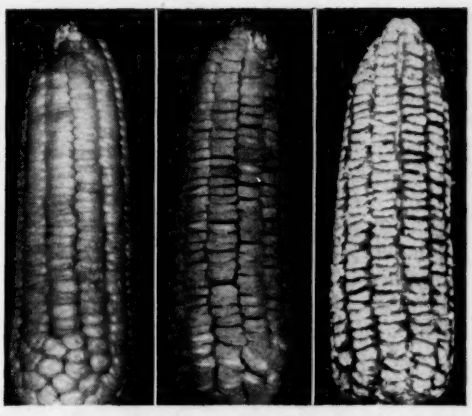
Insect attack was determined by examination with a binocular microscope; every grain having the seed coat broken by insect feeding or oviposition puncture

was recorded as infested. Several insects infesting the samples could not be accurately distinguished on this basis, but, judging from previous observations, it was evident that most of the damage found was caused by the rice weevil, the commonest insect encountered in all unfumigated replicates. The square-necked grain beetle, *Cathartus quadricollis* (Guér.),[1] was next in abundance. A few specimens of the bamboo powder-post beetle *Dinoderus minutus* (F). were found in some lots, and what was considered evidence of its feeding was quite general but did not exceed 4 per cent in any one sample. Larvae of the rice moth, *Corcyra cephalonica* (Staint.), were abundant after several months exposure, and the Indian meal moth, *Plodia interpunctella* (Hbn.), appeared after the grain had been badly damaged by other insects.

After examination for infestation, the 100 grains of corn in each sample were placed in a "rag-doll" type of canton-flannel germinator to determine viability. Observations were made at the end of 48 hours and daily thereafter until the end of 6 days. For the purposes of this investigation, all kernels were recorded as viable which produced a sprout or root that extended beyond the end of the seed during this time, and all others were considered dead.

COPPER CARBONATE DIP INEFFECTIVE.—With the idea of testing the earliest possible protection, the first experiment compared a home-made suspension of copper carbonate, which can be easily prepared from materials readily obtainable, with copper carbonate dust, carbon bisulfide fumigation, and no treatment. These treatments, listed in table 1, were applied as follows: The ears and grain used for treatment A (Table 1) received no treatment other than that outlined above. As harvested, the husked ears (Fig. 1, *A*) in treatment B were wet by frequent and rapid immersions for about 3 minutes in a water suspension of freshly precipitated

[1] Determined by W. S. Fisher, Bureau of Entomology and Plant Quarantine.



A *B* *C*

FIG. 1.—Seed ear of the USDA-34 variety of sweet corn typical of those used in seed protection tests: *A*, newly harvested; *B*, partly dried, 4 days after harvest, in proper condition for rolling in hydrated lime or other dust; and *C*, after rolling in hydrated lime. Note, in *B*, separation of grains essential for thorough coverage, and in *C*, penetration of dust between rows and grains. To treat 100 ears of this size (about 6 inches long) required 8 ounces of material.

Table 1.—Per cent infestation by storage insects and corresponding viability of copper-carbonate-treated and fumigated corn seed at specified periods after being harvested on October 22, 1942 (100 grains examined from each of 5 replicates per treatment at each period).

	INFESTATION AT—MONTHS			VIABILITY AT—MONTHS		
	1	2	4	1	2	4
A.—Check—untreated	68.0	99.2	100.0	88.2	74.2	28.0
B.—Copper carbonate water suspension applied to newly harvested ears by dipping	63.6	98.4	100.0	91.2	75.8	34.6
C.—Copper carbonate water suspension with wetting agent applied to newly harvested ears by dipping	70.8	99.4	100.0	92.0	78.0	27.4
D.—Copper carbonate dust mixed with shelled seed, 1–448, 1 mo. after harvest	56.6	84.4	100.0	85.4	77.2	51.2
E.—Carbon disulfide fumigation applied to shelled seed 1 mo. after harvest	66.8	72.2	98.6	78.6	87.8	75.4
Least significant difference		9.8			10.0	

copper carbonate made by combining equal parts of a solution of commercial copper sulfate, 20 pounds in 50 gallons of water, and a solution of commercial dry sodium carbonate, 9 pounds in 50 gallons of water. The ears in treatment C were similarly handled, but the suspension contained 1 ounce of a commercial wetting agent, sodium isopropyl naphthelene sulfonic acid, per 100 gallons.

In treatment D, after the usual drying in the ear, the shelled seed was treated with copper-carbonate dust at the rate of 2 ounces per bushel (1 to 448 by weight) after the method recommended by Essig & Hoskins (1944). A good distribution over each grain was secured by tumbling for about 5 minutes in an oven-size tin can turned on a diagonal axis.

In treatment E the shelled seed was fumigated for 24 hours with carbon disulfide at the rate of 20 pounds per 1000 cubic feet. At the end of this period the sacks containing these replicates were enclosed in a cage having wire-cloth screening fine enough to exclude the usual grain-infesting insects. This cage was kept in the same open shed where the replicates of all the other treatments were stored.

The corn used in this experiment was harvested on October 22, 1942, and treatments B and C were applied at that time. Typical newly harvested ears receiving these treatments are shown in Figure 1. In all treatments drying was sufficient that the corn could be shelled on November 20, and treatments D and E were applied then. Table 1 summarizes the infestation and viability in the first experiment at 1, 2, and 4 months after harvest.

It is evident in table 1 that a water suspension of copper carbonate, with or without a wetting agent, was ineffective; failure of both solutions to coat more than the outermost parts of the grains may have been partly responsible. Treating the shelled grain at 1 month after harvest with the dust form only delayed insect damage somewhat. The fumigated seed sustained less damage than any other, despite the fact that the isolation became accidentally broken a month before the last examination. Viability of the seed treated with copper carbonate was generally higher than that of the untreated, and (not shown in the table) more of the dusted seed germinated in 72 hours than of the untreated or of the dipped. However, the superiority of fumigation was reflected in maintenance of high viability up to 4 months after harvest.

Table 2.—Per cent infestation and viability at specified periods after harvest (January 22, 1943) of corn seed treated with copper carbonate and hydrated lime and fumigated against storage insects (100 seeds examined from each of 4 replicates per treatment at each period).

Treatment	Infestation at—Months			Viability at—Months		
	1	3	5	1	3	5
A.—Check—untreated	43.5	99.5	100.0	99.0	73.8	2.8
B.—Copper carbonate dust, 17.5 per cent, in lime applied to partly dried ears by rolling 3 days after harvest	.135	49.3	91.3	99.8	87.5	22.8
C.—Lime applied as in B	15.3	46.8	95.0	100.0	88.3	22.5
D.—Copper carbonate dust mixed with shelled seed, 1–448, 1 mo. after harvest	48.5	71.5	94.8	99.3	87.0	38.0
E.—Lime, 1–40, applied as in D	54.5	61.5	84.8	99.5	77.5	34.5
F.—Carbon bisulfide fumigation applied to shelled seed 1 mo. after harvest	50.8	51.8	54.0	99.3	97.3	66.9
Difference required for significance at—						
19 to 1 odds		16.7			12.9	
99 to 1 odds		22.1			17.1	

Hydrated Lime.—Since dipping the newly harvested seed ears in freshly precipitated copper carbonate was unsatisfactory for early protection, this method was discarded in favor of allowing the seed ears first to dry somewhat and then rolling them in copper carbonate dust diluted to 17.5 per cent with hydrated lime (Treatment B, Table 2). This was done about 3 days after harvest, when the grains had separated enough for the dust

to penetrate to the cob and thus come in contact with more of the surface of each grain. A seed ear in this condition before treatment is shown in figure 1, *B*, and after treatment in figure 1, *C*. Hydrated lime was also applied in the same way (treatment C), the ears in both treatments holding about 2 grams of dust each (about 8 ounces per 100 ears, equivalent to about 2.5 pounds per 100 pounds of shelled seed). This amount of the copper carbonate lime mixture was sufficient to equal approximately 2 ounces of chemical per bushel (1 part to 448 parts by weight), the dosage recommended by Essig & Hoskins (1944). It was estimated that one man could treat approximately 100 seed ears per hour by this dust-dip method, but the same operation could no doubt be done more rapidly by tumbling in a revolving drum, such as the ordinary dust mixer. In two other treatments (D and E), copper carbonate alone and hydrated lime alone at the above respective rates were mixed with the shelled seed, as in the previous experiment. In this second experiment the corn was harvested January 22, 1944, and four replications of each treatment were made; other conditions were the same as in the first experiment. The infestation and corresponding viability of the seed in each treatment is summarized in table 2.

Table 3.—Condition at 1, 3, and 6 months after harvest (March 14, 1944) of corn seed treated against storage insects with hydrated lime, phenothiazine, and phenoxathiin (expressed as per cent infestation and per cent viable seed) (100 seeds examined from each of 4 replicates per treatment at each period).

Treatment	Infestation at—Months			Viability at—Months		
	1	3	6	1	3	6
A.—Check—untreated	61.5	95.3	100.0	94.3	44.3	0.5
B.—Lime applied to partly dried ears by rolling 3 days after harvest	14.5	34.5	86.0	95.3	91.0	24.0
C.—Phenothiazine, 17.5 per cent, in lime applied as in B	33.3	45.0	79.3	95.0	86.0	20.8
D.—Phenothiazine mixed with shelled seed, 1–448, 1 mo. after harvest	90.0	88.0	100.0	92.5	77.3	1.3
E.—Phenoxathiin-bentonite with lime to contain 17.5 per cent of phenoxathiin applied as in B	26.3	31.5	96.0	97.3	92.8	21.8
F.—Phenoxathiin-bentonite (phenoxathiin 1–448), applied as in D	39.0	42.0	43.8	95.5	85.8	29.0
Difference required for significance at—						
19 to 1 odds		14.8			14.3	
99 to 1 odds		19.6			19.0	

At time of shelling, 1 month after harvest, the untreated seed was found to be 44 per cent infested and after 3 months totally so. However, in the seed shelled from the partly dry ears that were rolled in copper carbonate diluted with lime (Treatment B) and in lime alone (Treatment C) shortly after harvest, infestation was only about 15 per cent during the first month and below 50 per cent at 3 months, lower than that under any of the other treatments. Fumigation at time of shelling followed by insect-proof storage (Treatment F), held the infestation at about 50 per cent, whereas mixing copper carbonate alone with the shelled seed (Treatment D) was relatively ineffective, permitting at 3 months a significantly higher infestation than when applied with lime to the partly dried ears. Lime alone, mixed with the shelled seed 1 month after harvest, (Treatment E) gave practically the same results as when applied to the partly dry ears. None of the treatments other than fumigation was effective in preventing extensive infestation beyond 3 months.

The viability of about 100 per cent in all treatments 1 month after harvest decreased more rapidly in the untreated seed than in the treated as infestation increased. Less than 3 per cent of the untreated seed germinated at the close of the experiment 5 months after harvest. At 3 months the viability of the seed dusted in the ear stage was slightly higher than that of the shelled grain treated with the same materials, but after 3 months the viability

of all four lots decreased markedly; viability at 5 months was about half that of the fumigated seed. For preventing infestation and preserving viability up to 3 months after harvest the simple treatment of rolling the partly dry seed ears in hydrated lime was a big improvement over no treatment at all and gave as satisfactory rexults as fumigating the shelled seed with carbon-disulfide.

PHENOTHIAZINE AND PHENOXATHIIN.—In the third and last experiment, rolling the partly dry seed ears in hydrated lime was tested again and compared with similarly applying finely ground phenothaizine and a micronized grade of phenoxathiin (containing 46.5 per cent of bentonite) diluted with lime. These last two compounds, were also used alone by mixing with the shelled grain, as for copper carbonate dust in the previous experiments. All other conditions were the same, except that the seed ears were harvested on March 14, 1944. The condition of the seed following these treatments is summarized in table 3.

Rolling the partly dried seed ears in hydrated lime yielded practically the same results as in the previous experiment; the seed at each period after harvest was in better condition by high significance than the untreated, which was almost completely infested in 3 months.

Phenothiazine added to hydrated lime at 17.5 per cent concentration failed to increase protection, and used alone mixed with the shelled grain 1 month after harvest at 1 part to 448 parts by weight it was less effective and seemed to reduce viability. By either method of application phenothiazine was without practical value.

Phenoxathiin-bentonite added to hydrated lime to contain 17.5 per cent of phenoxathiin, and applied to the partly dried ears by rolling shortly after harvest, did not significantly improve control or affect germination over lime alone similarly applied. When mixed with the shelled seed 1 month after harvest it limited infestation to 43.8 per cent at 6 months, which was significantly better than any other treatment; although germination was high throughout, it did not differ significantly from that secured by rolling the seed ears in hydrated lime.

The change in color of phenothiazine recorded by Siegler & Smith (1942) was noted here, but it was more of a dark, dull purple and it developed mostly on the bleached-cheesecloth sacks used to hold the shelled seed, while the light-colored portions of the grains became tinged with a lighter purple. The addition of lime kept the color from becoming more than a light purple or pink. Some change in color was also noted when phenoxathiin-bentonite was used alone, and the sacks and the corn became slightly discolored but never with more than a tinge of dull pink. Where hydrated lime had been added to this chemical no color change was apparent.

SUMMARY AND CONCLUSIONS.—In warm climates corn seed becomes heavily infested by the rice weevil soon after harvest and, if kept under natural conditions, quickly loses its viability because of further attack by this and other storage insects. Experiments using the *USDA-34* variety of sweet corn showed that dipping the newly harvested seed ears in a freshly prepared water suspension of copper carbonate, with or without a wetting agent, did not prevent either early or late infestation. Mixing copper carbonate dust with the shelled seed 1 month after harvest at 1 part to 448 parts by weight, as recommended for smut control, was equally ineffective, although it tended to hasten sprouting. Phenothiazine at the same rate was not only ineffective, but also seemed to injure the seed. Phenoxathiin, as phenoxathiin-bentonite, kept the infestation lower and for a longer period than any other treatment except carbon-disulfide fumigation and isolation, but with no significant improvement in germination. Over a period of 6 months none of these dust treatments of shelled seed gave more satisfactory results than similarly applying hydrated lime at 1 part to 40 parts by weight.

Rolling the partly dried seed ears in hydrated lime alone or in lime containing copper carbonate, phenothiazine, or phenoxathiin-bentonite at a time when the grains had separated enough for the dust to penetrate to the cob (about 3 days after harvest), retarded early infestation and prevented serious damage during the first month after harvest. The dosage in all cases was adjusted so that the proportion of chemical used would be equivalent to 1 part to 448 parts by weight of seed after shelling and that of lime 1 to 40 parts (about 8 ounces per 100 ears). However, during the next 5 months of common stor-

age, none of these combinations produced significantly better control or germination than hydrated lime alone. Considering availability of material and practicability of timely application by the average farmer having seed to be held in common storage, rolling the partly dry seed ears in hydrated lime gave the most satisfactory results.—2-2-46.

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Beet Leafhopper Selection of Bean Varieties and Its Relation to Curly Top

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In southern Idaho the disease known as curly top reduces the yield of many important varieties of garden beans[2] and limits the area where they can be grown. The beet leafhopper, *Eutettix tenellus* (Baker), is the only known vector of the virus that causes the curly top disease. The earliest references to come to the writer's attention pertaining to curly top as a disease of beans are by Carsner (1925) and Merrill (1925). Carsner (1926) described the symptoms of the disease on beans and expressed the opinion that serious damage to the bean crop may be expected only in seasons when beet leafhoppers are relatively very abundant. The disease was considered serious by Harter & Zaumeyer (1944), who stated: "There is some reduction in yield every year; and, during years when the population of the insect that transmits curly top is large, the bean crop may be almost completely ruined." Larson & Hallock (1942) reported that curly top caused heavy loss to the bean crop of south-central Idaho during years of high beet leafhopper populations.

The study reported in this paper was undertaken to determine whether curly top limited the yields of all varieties of garden beans to the same extent, and to obtain additional information as to areas in south-central Idaho where susceptible beans can be grown during years of high leafhopper populations.

The general plan of this study places the observations on garden and field beans in three groups: (1) Selectivity studies in revolving cages, (2) selectivity studies in an entire greenhouse room, and (3) field observations in southern Idaho.

REVOLVING-CAGE STUDIES.—The selectivity studies in revolving cages were started by W. E. Peay during the winter of 1938 in the greenhouse, and continued by the writer each winter until the spring of 1942, to determine the relative attractiveness to the beet leafhopper of several varieties of garden beans in comparison with the Red Mexican field bean, which is highly resistant to curly top. The 20 varieties of garden beans used

[1] The investigations reported in this article were performed in general cooperation with the Bureau of Plant Industry, Soils, and Agricultural Engineering of the United States Department of Agriculture, the Idaho Agricultural Experiment Station, and the Idaho Plant Pest Commission.

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[2] The term "garden beans" refers to the edible-podded and other varieties eaten green, in contrast with those used only as dry, which are called "field" beans.

in this test were chosen because they are commonly grown for seed in south-central Idaho and often are injured severely by curly top. These tests were replicated 15 times.

The female beet leafhoppers used in these tests were collected from Russian-thistle, *Salsola kali tenuifolia* Tausch, in October of each year. They were stored in cages on beet plants in a cool room of the greenhouse, where the temperature ranged from 30° to 45° F., and were brought into the warm room of the greenhouse a few days before each test, so that they would be normally active when used. Approximately 31,000 female beet leafhoppers were used in testing these 20 varieties of garden beans.

The beans were grown in 4-inch flower pots from seed. They were used in the tests immediately after the first pair of true leaves had opened. Some plants were also tested in the crookneck, or cotyledon, stage, but no difference in attractiveness to the leafhopper was apparent, except in the case of one variety, Pencil Pod Black Wax.

The greenhouse temperature during these tests ranged from 70° to 80° F. during the day but occasionally dropped to 60° at night. As the cinder floor in the greenhouse was kept moist, the relative humidity ranged from 50 to 95 per cent, with an average of approximately 70 per cent.

Two revolving 4-compartment selectivity cages described in detail by Gillett & Douglass (1939) were operated in the greenhouse. Four bean plants, 2 Red Mexican and 2 of one of the test varieties, were placed in position on the floor of each cage. The upper portion of the cage was then lowered into position and secured with latches to the floor of the cage. The partitions were raised so that the leafhoppers could have free access to any of the 4 plants, and then the electric motor, which revolved the cage once in every 97 seconds, was started. One hundred female beet leafhoppers were introduced through a pipette into the center of each cage. The partitions were lowered at the end of about 23 hours and the revolving cages were stopped. The leafhoppers found in each compartment both on and off the plants were counted and the numbers were recorded. These cages were so constructed and operated that light and temperature factors were equalized and the insects were free to select any of the plants contained in the cage. In tests with beans no statistical differences were shown in the number of leafhoppers distributed in the 4 compartments when all plants were of the same variety and as nearly alike as possible.

The distribution of living leafhoppers on beans at the end of the tests is presented in table 1. The data were analyzed to determine whether the deviation from a 50:50 hypothesis was significant in the case of each garden variety. All garden-bean varieties tested in the true-leaf stage, except Pencil Pod Black Wax, were found to be significantly more attractive (at odds of 19 to 1) to the beet leafhopper than was the Red Mexican field bean. In the cotyledon stage however, Pencil Pod Black Wax was also significantly more attractive than the Red Mexican field bean.

Table 1.—Preference shown by the beet leafhopper for garden-bean varieties when released in lots of 100 in a revolving cage containing 2 plants of the test variety and 2 of the Red Mexican field bean, plants being in the true-leaf stage, 15 replicates, 1938–45.

Test Variety	Tests in Which More Leafhoppers[1] Were Located on—		Total Leafhoppers on Plants at End of Tests	
	Test Variety	Red Mexican	On All Plants	On Test Plants
	Number	*Number*	*Number*	*Per cent*
Bountiful	13	2	492	65.6
Red Valentine	15	0	626	65.7
Kentucky Wonder	15	0	667	63.7
Longfellow	13	1	639	62.1
Plentiful	15	0	596	61.7
White Kidney	12	2	651	60.5
Dark Red Kidney	13	2	728	60.3
Wardwell Wax	15	0	645	60.3
Pencil Pod Black Wax[2]	15	0	666	60.2
Pencil Pod Black Wax	4	6	426	46.7
Tennessee Greenpod	13	2	660	59.7
Asgrow Stringless Greenpod	14	1	643	59.4
Full measure	14	0	712	59.4
Burpee Stringless Greenpod	15	0	520	59.2
Sure Crop Black Wax	14	0	686	58.9
Tendergreen	14	0	692	58.8
Golden Wax	15	0	709	57.7
Landreth Stringless	11	4	634	57.2
Asgrow Black Valentine	9	4	629	55.3
Idaho Refugee	10	4	508	55.1
Round Pod Kidney Wax	11	3	669	54.5

[1] Where total is not 15, no preference was shown in some tests.
[2] Plants of test and check varieties were in the cotyledon stage.

Since these garden beans were more attractive to the leafhopper than Red Mexican beans, the results reported by Giddings (1944), that beans were most susceptible to many strains of the curly

top virus during the cotyledon stage, become more important to the grower of garden beans, especially Pencil Pod Black Wax. Field observations in south-central Idaho indicated that many varieties, such as Bountiful, Kentucky Wonder, and Plentiful, shown in these tests to be preferred by the leafhopper, were very susceptible to curly top. The data indicate that Round Pod Kidney Wax, Idaho Refugee, and Asgrow Black Valentine were only slightly more attractive to the beet leafhopper than was Red Mexican.

GREENHOUSE-ROOM STUDIES.—To determine the relative development of curly top on 19 varieties of garden beans, as compared with the check varieties, when exposed to large numbers of viruliferous beet leafhoppers, an experiment was conducted in an insect-tight room in the greenhouse. Eleven hundred 4-inch pots, each pot containing 2 plants, were grouped in 10 blocks, with 5 pots of each variety arranged at random in each block. This test required about 45 days, and was made four times during the period 1940–42.

With a few exceptions, the same varieties were used as in revolving-cage tests. The check plants consisted of Red Mexican and two Great Northern varieties (U. I. 15 and U. I. 123), which are commercial dry beans widely grown in south-central Idaho. Murphy (1940a, 1940b) showed that Red Mexican and Great Northern U. I. 15 were resistant to curly top. Great Northern U. I. 123 was somewhat resistant to curly top when compared with highly susceptible varieties of garden beans.

Beet leafhoppers were collected from Russian-thistle and were placed on beets infected with virulent strains of curly top, where they were kept for at least 24 hours before they were released over the bean plants. When a few beans had developed to the early cotyledon stage, about 1,000 of these beet leafhoppers were distributed over the young beans. Additional viruliferous beet leafhoppers were released in this room each day for a week, or until all the beans had developed beyond the cotyledon stage. Approximately 4000 leafhoppers were used in each test.

Two curly top readings were made during each test, the first about 1 month after the start and the other at the end of the test. At each reading, all bean plants that had developed curly top were removed, since the period of infection occurs during the early stage of the bean development and few or no leafhoppers remained alive in the room during the last 15 days of the tests. The plants that showed no signs of curly top at the end of each test were recorded and listed as healthy plants. The results of these tests are tabulated below.

Variety	*Per cent of plants infected*
Plentiful	62.4
Bountiful	58.5
Longfellow	57.9
Asgrow Black Valentine	57.3
Pencil Pod Black Wax	55.3
Sure Crop Black Wax	52.7
White Kidney	46.6
Golden Wax	43.5
Red Valentine	41.3
Tendergreen	32.9
Fullmeasure	30.5
Asgrow Stringless Greenpod	28.8
Round Pod Kidney Wax	27.0
Keeney's Stringless Green Refugee	26.6
Idaho Refugee	20.6
Wardwell Wax	20.1
Low's Champion	20.0
Dark Red Kidney	18.0
Landreth Stringless	11.3
Great Northern No. 15	1.7
Great Northern No. 123	1.0
Red Mexican	0
Difference required for significance, odds 19:1	5.5

An analysis of variance shows highly significant differences between many of the varieties in the percentage of plants infected. There was no significant difference between such highly attractive varieties as Plentiful, Bountiful, Longfellow, and Asgrow Black Valentine. Although Landreth Stringless, Dark Red Kidney, Low's Champion, Wardwell Wax, and Idaho Refugee showed significantly less curly top than the other 14 varieties of garden beans under the conditions of these tests, they have been severely injured by curly top in the field in years when leafhopper populations were high.

FIELD OBSERVATIONS.—Annual surveys of fields of Great Northern field beans and of different varieties of garden beans were made about the middle of July in the years 1935 to 1945 to determine the extent of the loss caused by curly top. Each year 100 plants in 4 locations in each of 60 to 71 fields of garden beans and in 40 fields of Great Northern beans (not including *Great Northern U. I. 15*) were examined. These fields were distributed over the

Twin Falls-Jerome irrigation district in south-central Idaho.

It is probable that the report of damage in these surveys was conservative, as many of the fields that showed excessive damage during years of high beet leafhopper populations were plowed out before the survey. An earlier survey would have given an erroneous picture of the curly top situation in the entire area, for only a portion of the diseased plants had developed sufficiently to be observed when the growers concluded that the beans in severely damaged fields had no value and plowed them up. Published records by Annand *et al.* (1932) show that Great Northern beans were severely damaged in 1930. No records are available for the period 1931 to 1934, but high leafhopper populations were recorded during some of these years and damage may have occurred. The 1935, 1936, and 1937 surveys were less extensive and covered only limited areas, as compared with the more recent surveys. The surveys during the period 1938 to 1945 gave extensive information on the percentage of the plants infected with curly top, the location where they were grown, and the varieties of garden beans in each field examined.

The data presented in table 2 show that 1930, 1935, 1937, and 1941 were years when serious losses were incurred by growers of beans in south-central Idaho. Heavy damage was also noted in a few fields of garden varieties during the 1940 and 1945 seasons.

Table 2.—Injury to garden and field beans by curly top in fields of south-central Idaho, 1930–45.

	Percentage of Plants Showing Curly Top Injury			
	Garden Beans		Great Northern Field Beans[1]	
Year	Range	Average	Range	Average
1930[2]	—	—	0–96	30.7
1935	—	—	1–69	18.8
1936	3– 5	—	—	—
1937	0–99	44.5	3–49	16.8
1938	0–14	2.2	0– 7	1.2
1939	0– 3	.6	0– 1	.2
1940	2–44	9.2	0– 9	2.5
1941	1–60	12.9	0–58	10.5
1942	0–10	1.3	0– 4	.2
1943	0– 2	.3	0– .3	.04
1944	0– 8	1.0	0– .3	.2
1945	0–79	7.7	0–13	2.7

[1] *Great Northern U. I. 15* beans not included in these surveys.
[2] See Annand *et al.* (1932).

Although the average loss to growers of garden beans during the 8-year period 1938 to 1945 was often low, some varieties were damaged more severely than others. A survey of 501 fields shows that Plentiful, Bountiful, Kentucky Wonder, and Asgrow Black Valentine were injured more often than the other varieties of garden beans generally grown for seed in south-central Idaho (Table 3). The laboratory studies indicated that Asgrow Stringless Greenpod occupied a median position, both in regard to the number of leafhoppers attracted to it in the revolving-cage tests (Table 1) and in the percentage of curly top that developed in the greenhouse tests. The field surveys, however, showed that 2 per cent of the Asgrow Stringless Greenpod and Tendergreen fields were injured more than 25 per cent (Table 3). These varieties may have shown a higher percentage of curly top under field conditions than other garden beans equally attractive to the beet leafhopper, because some growers classify them as resistant to curly top and often plant them where leafhoppers are expected to be abundant. The surveys indicate that Burpee Stringless and Golden Wax were fairly resistant; yet 43.5 per cent of the Golden Wax plants developed curly top in the laboratory tests (see tabulation p. —). In the selectivity tests (Table 1) Landreth Stringless, Dark Red Kidney, and Low's Champion were less attractive than were the other garden beans generally grown in south-central Idaho, and less curly top developed in these varieties under greenhouse conditions. Not enough fields of these varieties were observed, however, to indicate the amount of curly top developing under field conditions. Since only a few fields of Tennessee Greenpod were observed in south-central Idaho, that variety was not included in the laboratory studies, but recent field observations indicated that it is susceptible to curly top. As Keeney's Stringless, Commodore, Resistantia, Horticultural, Black Creaseback, Brittle Wax, California Birdseye, and Top Notch are not grown frequently in south-central Idaho and only 1 or 2 fields of each have been graded for curly top, they were given last in table 3.

These surveys also show that the amount of curly top injury is not equal in all parts of the bean-growing area of

south-central Idaho (Fig. 1). These differences are emphasized in years of high leafhopper populations. Annand *et al.* (1932) recorded serious crop losses in Great Northern dry-bean fields in 1930 and stressed the decrease in percentage of diseased plants toward the eastern part of the irrigated tract; thus, curly top in Great Northern beans in July 1930 averaged 80 per cent around Buhl, 34 per cent near Filer, 15 per cent at Kimberly, and 3 per cent in the vicinity of Burley. The 1935 survey of curly top in Great Northern beans showed that injury in July averaged 45 per cent around Buhl, 9 per cent in the Twin Falls-Kimberly tract, 42 per cent around Murtaugh, and 6 per cent in the vicinity of Burley.

Table 3.—Curly top injury to different varieties of garden beans in south-central Idaho, 1938–45.

Variety	Fields Examined	Percentage of Fields Showing Curly Top to the Amount of— 5% or More	10% or More	25% or More
	Number			
Plentiful	24	46	25	13
Kentucky Wonder	31	35	29	13
Bountiful	51	33	18	8
Asgrow Black Valentine	37	24	16	8
Asgrow Stringless Greenpod	58	22	9	2
Red Valentine	10	60	40	0
Fullmeasure	9	22	22	0
Pencil Pod Black Wax	18	39	17	0
Sure Crop Black Wax	10	20	20	0
Idaho Refugee	21	19	10	0
Round Pod Kidney Wax	26	12	8	0
Girant Stringless	33	15	6	0
Tendergreen	46	11	4	2
Burpee Stringless	85	9	0	0
Golden Wax	13	8	0	0
Landreth Stringless	10	0	0	0
Low's Champion	4	0	0	0
Tennessee Greenpod	4	50	25	25
Dark Red Kidney	2	0	0	0
Keeney's Stringless	2	0	0	0
Commodore	1	100	100	100
Resistantia	1	100	100	0
Horticultural	1	100	100	100
Black Creaseback	1	0	0	0
Brittle Wax	1	0	0	0
California Birdseye	1	0	0	0
Top Notch	1	0	0	0
Total	501	22	12	4

The 1938 to 1945 field surveys of garden-bean varieties were summarized by locality, and the results indicated that the amount of curly top injury to garden beans is not the same in all parts of the Twin Falls-Jerome tract (Table 4). The data in this table indicate that garden beans in fields around Berger, Buhl, Clover, and Murtaugh were often severely injured by curly top. Extensive damage would also be expected in the vicinity of Jerome and Wendell, except that beans of the garden varieties are seldom planted west of Jerome during years of high leafhopper populations.

Table 4.—Curly top injury in garden-bean fields in various localities in south-central Idaho, 1938–45.

Locality	Fields Examined	Percentage of Fields Showing Curly Top to the Amount of— 5% or More	10% or More	25% or More
	Number			
Buhl	26	54	35	23
Clover	10	40	30	10
Wendell	10	40	30	10
Murtaugh	42	31	21	5
Berger	49	29	10	8
Jerome	59	19	8	5
Hazelton	38	29	16	3
Eden	78	21	10	1
King Hill	4	25	25	0
Filer	26	19	8	0
Twin Falls	71	14	6	0
Kimberly	37	5	3	0
Hansen	51	6	2	0
Total	501	22	12	4

Although the percentage of fields recorded as showing more than 25 per cent of curly top injury to varieties of garden

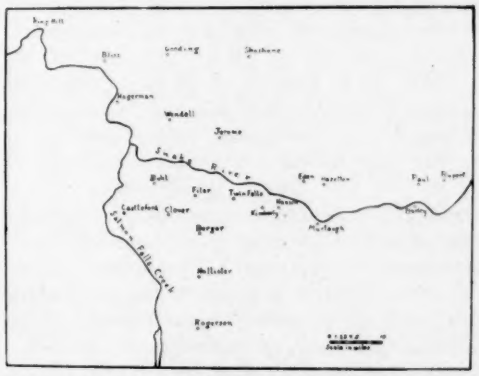

FIG. 1.—Localities in south-central Idaho where gardens beans are grown extensively.

beans is higher around Eden and Hazelton than in many of the localities south of the Snake River, there are large areas within the Eden and Hazelton districts where very little curly top was evident, even in 1941 and 1945, years of high incidence of the disease. There are small local leafhopper-breeding areas within these districts, and the curly top losses have usually occurred near such breeding areas.

In many districts the growers are aware of this danger, and few or no varieties of garden beans are grown under contract around Castleford, Buhl, Jerome, Wendell, and other localities in the extreme western portion of the Twin Falls-Jerome tract, except in years when the leafhopper population is expected to be very low. In 1944, when curly top injury had been very low for several years, susceptible beans were planted commonly around Jerome and Wendell. In 5 fields near Wendell included in the 1944 survey, curly top injury ranged from 2 to 3 per cent, as compared with an average of 1 per cent (Table 2) for the entire 62 fields surveyed in 1944. Five fields of garden beans near Wendell were examined in 1945, when a medium population of beet leafhoppers moved into the cultivated area late in the season. The percentage of plants infected with curly top in these fields ranged from 1 to 40, with an average of 17 per cent, as compared with an average of 7 per cent for the other 55 fields surveyed in south-central Idaho in 1945. Severe losses can be expected around Wendell during years of high beet leafhopper populations.

The variations in damage to beans, indicated in the different parts of the Twin Falls-Jerome tract, seem to parallel closely those where extensive curly top injury often occurs in beets in the same area. Annand *et al.* (1932), Douglass *et al.* (1943), and Fox *et al.* (1945) indicated that the west end of the cultivated areas of south-central Idaho normally receives a heavier infestation of beet leafhoppers than do the areas farther east; consequently, susceptible crops in those areas are damaged during years of high leafhopper populations. The surveys have shown extensive damage in the same areas in years when extensive movements of the spring-generation leafhoppers coincide with the cotyledon stage of the beans. Although garden beans planted just before or at about the start of the spring migration in the Twin Falls district and in the district immediately east of Twin Falls should nearly always escape severe injury (Larson & Hallock 1942), it is not safe to plant susceptible varieties in areas where heavy damage from curly top may be expected during years of high leafhopper populations.

The more susceptible varieties of garden beans can be expected to incur losses when planted near Berger, Buhl, Clover, Jerome, King Hill, Murtaugh, Wendell, or in other communities in the western part of the irrigated area of south-central Idaho during years of high leafhopper populations. The central area, extending from Hansen through Kimberly, Twin Falls, and beyond Filer, generally shows less curly top injury to susceptible beans than is evident in the remainder of the Twin Falls-Jerome tract.

SUMMARY AND CONCLUSIONS.—Selectivity tests, in special revolving cages, of 20 varieties of garden beans commonly grown in south-central Idaho showed that a significantly higher percentage of beet leafhoppers, *Eutettix tenellus* (Bak.), chose the garden varieties in preference to the curly top-resistant field variety, Red Mexican. The data indicated that Red Valentine, Bountiful, Kentucky Wonder, and Plentiful were the most attractive varieties.

Greenhouse tests showed that Plentiful, Bountiful, Longfellow, Asgrow Black Valentine, Pencil Pod Black Wax, and Sure Crop Black Wax developed significantly more curly top than did the remaining 13 varieties when a large number of viruliferous leafhoppers were allowed a choice. All 19 varieties of garden beans showed significantly more curly top than either Red Mexican or Great Northern commercial dry beans.

The results obtained in the greenhouse tests generally hold true under field conditions in south-central Idaho, as the varieties most severely injured by curly top in the greenhouse were also most severely injured by curly top in the field. the greatest damage occurring in areas having high leafhopper populations. The results indicate that in years of medium leafhopper populations such varieties as Burpee Stringless Greenpod, Idaho Refugee, and Landreth Stringless Greenpod can be grown in south-central Idaho with less danger of loss from curly top than can

the other garden varieties. It is concluded that losses in bean yields can be decreased in south-central Idaho by avoiding the use of highly susceptible varieties in years when high leafhopper populations are expected.—1-21-46.

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THE MOSQUITOES OF THE SOUTHERN UNITED STATES EAST OF OKLAHOMA AND TEXAS, by Stanley J. Carpenter, Woodrow W. Middlekauff and Roy W. Chamberlain. 1946. 292 pages, 155 figures. The American Midland Naturalist Monograph No. 3. University of Notre Dame, Notre Dame, Indiana. Clothbound, postpaid, $4.00.

The war provided the authors of this work unequalled opportunity to make an exhaustive study of the mosquitoes of the region covered and this work demonstrates that the opportunities were utilized to the fullest extent. While the area covered is defined as the Southern United States the material included is sufficient to make the information useful over the entire area east of the Rocky Mountains even though it may not be quite comprehensive for some portions o' that territory.

The introductory portion of the work discusses the bionomics of mosquitoes, their relation to disease and their consequent importance in the field of medicine as well as a very useful section on collecting and mounting adults and larvae, dissecting for study of malaria parasites, rearing larvae and technique for the identification of adults, larvae and eggs. In the discussion of identification the morphological characters involved are described and well illustrated so that any entomologist should be able to make reliable determinations of the species which may be found in his area. The keys and descriptions include 11 genera and 73 species. For each of these is given, in addition to the structural characters needed for identification, a summary of distribution and of the bionomics including breeding places, biting habits, seasonal abundance and medical importance.

Keys are provided to separate the subfamilies of the Culicidae but for tribes, genera and species the keys are confined to the Culicinae or mosquitoes proper. A bibliography of 188 references to literature is not the least important feature of the monograph.

The contribution of the illustrations to the value of the work can scarcely be over-stressed. The drawings are credited to Mrs. Elizabeth Kaston and are all clear and well-executed. The publishers have allowed ample space for the illustrations, all of them being half-page or larger in size. They are well indexed and should be entirely usable even by the tyro in the field.

The prompt appearance of this work is an additional merit which should not be overlooked. Potential users can now have access to the information contained while the interest in the subject is still active and the supplementary information about the actual status of mosquitoes in parts of the territory not covered in detail in the course of the work of the Sanitary Corps which should be recorded as a result of the stimulus of the work of Dr. Carpenter and his associates will necessarily be credited to this work.

Entomologists can do no less to show their appreciation than to add the work to their personal libraries and insist that it be placed in their institutional libraries. The volume is well printed and attractively bound.

Natural Enemies of Some Arizona Cotton Insects

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In the course of dusting experiments for the control of hemipterous cotton insects in the Yuma Valley region of Arizona and California during the summer of 1937, incidental observations were also made on the natural enemies of certain of these insects. Since little is known regarding this phase of the problem and because certain species are important as control agents, the information obtained is made available to other workers.

Euschistus impictiventris Stål.—This pentatomid is without doubt the most serious insect pest of cotton in the Yuma Valley. Infestations are characterized by rapid population shifts from other host plants to cotton as the bolls are forming. On July 26 there were on an average nearly two adults per plant in one field near Somerton, Ariz., and egg masses were appearing in abundance. Many of these eggs were parasitized, and others were being consumed by an unknown predator that left only the jagged basal portions adhering to the leaves. A small malachiid beetle that occurred abundantly on the plants was immediately suspected, and feeding tests soon confirmed its activity. Specimens were determined by H. S. Barber as *Collops marginellus* Lec., while specimens of the egg parasite from the same field were identified as *Telenomus mesillae* (Ckll.) by C. F. W. Muesebeck.

In order to ascertain the full extent of natural control under field conditions, each egg mass was tagged as located. Only fresh eggs with unbroken shells were selected. These were visited at about weekly intervals until emergence was complete, when final data were obtained on parasitization and predation. This method has the advantage of leaving the host species undisturbed; if collected for rearing before emergence is completed, many eggs are removed which otherwise would have been subject to attack. The effect of both parasite and predator upon *Euschistus* eggs during the peak of oviposition is shown in table 1.

It will be noted that *Collops* destroyed more than twice as many eggs as did *Telenomus*, while the combined attack by both species averaged 61.4 per cent. Subsequent dissections showed, however, that most of the 71 intact eggs contained dead immature stages of *Telenomus*, which raised the average for that species by about 5 per cent and the combined total destruction to about two-thirds of the eggs deposited. The scarcity of *Euschistus* nymphs during the following weeks was undoubtedly due largely to the activities of these natural enemies.

Because of its small size, the adult *Collops* is frequently unable to devour all the eggs in each egg mass encountered. Of the 670 eggs in the 32 masses which were attacked, 570, or 85.1 per cent, were destroyed. However, nymphs rarely hatch from an egg mass containing any parasitized eggs. In competition, though, *Collops* is intrinsically superior to *Telenomus*, inasmuch as parasitized eggs are devoured as readily as those unparasitized.

Table 1.—Effect of natural enemies upon *Euschistus impictiventris* eggs on cotton, Somerton, Ariz., 1937.

Date Tagged	Number of Egg Masses	Total[1] Number of Eggs	Per Cent Natural Control		
			Telenomus	*Collops*	Total
July 23	6	109	17.5	29.1	46.6
26	19	339	17.9	27.7	45.6
30	14	302	29.9	53.2	83.1
31	14	326	9.5	64.3	73.8
Aug. 4	6	106	13.1	29.3	42.4
11–13	11	217	20.0	29.3	49.3
Totals and averages	70	1,399	18.5	42.9	61.4

[1] Includes 71 blanks; these were disregarded in calculating percentages.

Laboratory feeding tests were performed in which *Euschistus* eggs and first-instar nymphs were used with *Collops* and the following species of predatory Hemiptera that occur abundantly in Arizona cotton fields: *Geocoris sonorensis* Van D., *Nabis ferus* (L.), *Sinea undulata* Uhl., and *Zelus renardii* Kolen. *Collops marginellus* Lec. could not be induced to attack the nymphs, showing a decided preference for eggs only. Furthermore, none of the Hemiptera would attempt to pierce the eggs although confined without other food until all were dead. Both *Zelus*

[1] The author acknowledges the assistance of John M. Breazeale.

renardii and *Sinea undulata* readily attacked moving first-instar nymphs, impaling them upon the proboscis and rapidly subtracting the body fluids. These species would attack only moving prey, and invariably ignored motionless nymphs.

Chlorochroa sayi Stål.—This common pentatomid was predominantly an alfalfa pest until about midsummer, when it gradually replaced *Euschistus impictiventris* as the primary boll-punctuirng species. As the cotton bolls ripened a second general migration occurred, this time to grain sorghums during late summer and autumn. Because of the higher populations existing on alfalfa and sorghums, observations were confined largely to these two host plants.

It was necessary to adopt the method of collecting egg masses for rearing before emergence was completed. A total of 1,704 *Chlorochroa sayi* eggs were obtained on July 20 in a very heavily infested alfalfa field at Bard, Calif., across the Colorado River from Yuma; 6.9 per cent of these eggs produced adult parasites. Six specimens were identified by A. B. Gahan as *Ooencyrtus johnsoni* (How.), the remainder being *Telenomus mesillae*. Parasitization gradually increased as the season advanced, until on October 4, 95.9 per cent of 664 eggs collected from grain sorghums in the Bard Experiment Station variety plots were parasitized. *T. mesillae* was again the dominant species, although 17 specimens were determined by C. F. W. Muesebeck as *Telenomus podisi* Ashm. Since the egg parasites apparently required most of the season to build up effective populations, their greatest benefit was in the reduction of late-generation nymphs, which otherwise would have produced large numbers of overwintering adults. Although wide seasonal fluctuations were thus caused, the average host density was no doubt greatly lowered. This situation might possibly be improved by early-season mass releases of *T. mesillae* in the heaviest infestations, or by introducing other species which may be more efficient at low host-population densities.

Caffrey & Barber (1919) reared *Telenomus mesillae* (= *T. ashmeadi* Morr.) from about 60 per cent of *Chlorochroa sayi* eggs collected during midsummer in badly infested New Mexico grain fields. Here the life cycle occupied from 17 to 26 days, whereas at Yuma only 12 to 17 days elapsed in October. With an average life cycle of about 2 weeks during the summer months, the parasite was able to complete two or more generations to each of its hosts in southwestern Arizona. *T. mesillae* is known to occur also in Texas, California, Utah, and Alberta, Canada. Additional hosts are *Chlorochroa ligata* (Say) and *Thyanta custator* (F). (Gahan 1932). Development is hypermetamorphic, as in other Scelionidae, with the usual minute teleaform primary larva. When several females were confined with a single egg mass, they repeatedly attacked one another, although no animosity was shown in the absence of host eggs. Further biological details are given by Caffey & Barber (1919) and Morrill (1907).

Laboratory feeding tests with the same predatory insects against eggs and newly hatched nymphs of *Chlorochroa sayi* gave results similar to those obtained with *E. impictiventris*. *Collops marginellus*, however, was unable to penetrate the much heavier egg shell of *C. sayi*, although attacked with equal readiness. Furthermore, none of the eggs observed on alfalfa, cotton, or sorghums showed evidence of feeding by *Collops*. *Collops bipunctatus* (Say) is recorded by Caffrey & Barber (1919) in New Mexico, and by Strand (1937) in Montana, as an effective egg predator of *C. sayi*. Further observations on the feeding habits of this and other species of *Collops* are given by Knowlton (1944). The introduction of *Collops bipunctatus* into the Yuma Valley would therefore seem highly desirable.

Occasional specimens of a large larvaevorid were reared from field-collected *Chlorochroa sayi* adults, subsequently identified by D. G. Hall as *Gymnosoma fuliginosum* R. D. In an attempt to determine its relative abundance and possible value, 1083 *C. sayi* adults were swept from several heavily infested alfalfa fields in 7 collections from July 20 to October 1. These were placed in large screen cages and kept supplied with alfalfa sprigs and cotton stalks containing green bolls. Upon emerging the mature tachinid larvae pupated readily on the floor of the cage. Only 20, or 1.8 per cent, were parasitized, a maximum of 4.0 per cent being recorded in one collection. None of the 54 *Euschistus impictiventris* and 22 *Thyanta custator* adults from the same fields produced

parasites. Although a slight increase occurred during late summer, this species was obviously of little value as a control agent. *G. fuliginosum* is widely distributed in the United States and also occurs in Puerto Rico and Mexico. *C. sayi* is the only recorded host.

The mode of attack of *Gymnosoma fuliginosum* was observed repeatedly in a screen cage containing numerous adult bugs. Upon encountering its host, the female fly would jump quickly upon the dorsum, causing the host to drop to the floor of the cage with wings outspread. After they had rolled over together several times, the parasite would suddenly free itself and walk away, while the bug also regained its feet, flitting its wings several times before furling them. One female thus attacked 18 bugs in less than an hour. Since Morrill (1910) has stated that eggs are usually deposited on the sides of the body on the ventral prothoracic region, these individuals were minutely examined but no eggs could be found. After an extended search, however, they were located beneath the posterior portion of the scutellum. This area is exposed only when the wings are raised in flight, thus explaining the singular mode of attack just described. The eggs appear as tiny, soft, elongate-oval, whitish objects with a prominent raised micropyle at one end.

Additional information on the biology of *G. fuliginosum* is given by Caffrey & Barber (1919).

Bucculatrix thurberiella Busck.—The cotton leaf perforator frequently causes severe damage to the foliage in the arid Southwest, particularly during late summer. While developing as a leaf miner during the first larval instar, the perforator is subject to attack by a minute pteromalid, *Closterocerus utahensis* Cwfd. (detd. by A. B. Gahan). After the host larva has been paralyzed, the microscopic oval egg is deposited in the body cavity, where the parasite larva hatches and feeds until mature, when it emerges from the host and comes to lie within the leaf mine. The pupa is strongly flattened to fit the mine and shortly before transforming to the adult is readily discernible by its jet-black color. Although superparasitization is common, only one parasite emerges per host. The life cycle of *C. utahensis* requires only 12 to 15 days during midsummer. Unparasitized larvae leave a typical horseshoe-shaped exuvia, while those previously parasitized are indicated by the twisted larval skin outstretched at the end of the mine.

In order to determine the extent of parasitization, several samples of 50 inhabited leaf mines were collected at random in heavily infested cotton fields from September 21 to October 26. Of the 250 larvae thus obtained, 201, or 80.4 per cent, yielded parasites. Observations also showed that parasitization failed to become effective until late in the season, after the perforator had caused most of its damage. Thus, even though overwintering populations are greatly reduced and the pest is maintained at a lower average density than would otherwise obtain, *Closterocerus utahensis* probably cannot be considered an efficient parasite in the Yuma Valley.

No attempt was made to rear parasites from the larger perforator larvae, but 4 species of cocoon parasites were obtained as follows (detd. by A. B. Gahan and C. F. W. Muesebeck): *Catolaccus aeneoviridis* (Gir.), *Spilochalcis side* (Walk.), *Haltichella* n. sp., and *Hormis* n. sp. Eight collections, totaling 552 cocoons, were obtained in two infested fields from July 14 to September 25, and each cocoon was isolated in a gelatin capsule for rearing. Total parasitization ranged from 8.7 to 84.2 per cent, with an average of 24.2 per cent in the entire series. *C. aeneoviridis* was most numerous with 7.2 per cent; 4.0 per cent were *S. side*, 3.3 per cent *Haltichella* n. sp., and 0.2 per cent (one specimen) *Hormius* n. sp.—3-20-46.

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Control of Bollworm and Cotton Flea Hopper by DDT

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Laboratory, cage, and field tests with DDT for control of several of the more important cotton insects were conducted at Waco, Tex., in 1943 and 1944. These tests showed that DDT applied as a dust was equal to or slightly better than the standard recommended insecticides for control of the bollworm, *Heliothis armigera* (Hbn.), and the cotton flea hopper, *Psallus seriatus* (Reut.), but not so good against the boll weevil, *Anthonomus grandis* Boh., or the cotton leafworm, *Alabama argillacea* (Hbn.). Results of the 1943 and 1944 tests have been published by Ivy (1944), Ivy & Ewing (1945), Ewing & Parencia (1945). and Ivy *et al.* (1945).

Cage and field tests were conducted during 1945 to compare DDT sprays and dusts at various concentrations of DDT with different diluents against the bollworm, the cotton flea hopper, and several other cotton-insect pests.

Injury to Cotton from DDT-Oil Sprays.—Prior to these tests a number of DDT formulations containing various types of oil were sprayed on cotton plants with a modified nasal atomizer at rates ranging from 1 to 20 gallons per acre. From moderate to severe injury was obtained with kerosene, xylene, and three commercial horticultural-oil preparations. Slight injury was obtained at the highest dosages of light mineral oil and heavy petroleum distillate, but there was no discernible injury at applications lower than 10 gallons per acre with these materials.

The cage tests were conducted over a period of six weeks, on extremely tender, succulent cotton. The petroleum-distillate sprays showed an occasional injured leaf when improper distribution caused too great a concentration of the oil. Moderate to severe injury occurred only once, on July 13. On this occasion a light mist fell immediately after the plants were treated and evidently prevented evaporation of the oil for several hours. Minute brownish spots appeared. In addition, the moisture caused the fine droplets of oil to run together and produce larger areas of severe burning.

On July 14 a tractor spraying device designed to disperse an atomized mist by means of an air blast from a rotary fan was tested to determine whether it could be used for field applications of DDT-petroleum distillate spray. The machine failed to atomize the material sufficiently, the distribution over the plants was very poor, and moderate to severe injury resulted from one application at 3 gallons per acre. Owing to lack of equipment for applying the oil sprays properly in the field, and to the possibility of causing plant injury, this material was not included in the field tests.

Bollworm.—*Cage tests.* Four series of cage tests were conducted to compare the effectiveness of various DDT dusts and sprays against insectary-reared third-instar bollworms. Accurately controlled dosages were applied to field-grown cotton plants in a settling chamber in the manner previously reported (Ivy 1944), except that air from a pressure tank at 60 to 80 pounds per square inch was used to propel the dust and spray charges. The sprays were applied through a modified nasal atomizer. The mortality records are shown in table 1.

In series 1 solutions of DDT in heavy petroleum distillate (Diesel oil) at 3 gallons per acre gave much quicker kills than DDT-pyrophyllite dusts at corresponding dosages of DDT. At the end of five days, however, the dusts approximately equaled the sprays in effectiveness.

In series 2 the effectiveness of a 3.6 per cent DDT-petroleum distillate spray was reduced when the rate of application was lowered from 3 gallons to 2 and 1 gallon per acre, but there were no important differences when the DDT content was increased to 5.4 and 10.8 per cent at the lower rates of application to bring the total amount of DDT per acre to 0.8 pound in each treatment.

In series 3 DDT-petroleum distillate spray was compared with 5 per cent DDT-pyrophyllite dust and with DDT emul-

[1] In cooperation with the Texas Agricultural Experiment Station.

[2] Thanks are extended A. B. Beavers for a large portion of the routine field-plot records made in the experiments at Port Lavaca.

Table 1.—Mortality of third instar bollworms following treatment with various formulations of DDT.

Formulation	Concentration of DDT	Rate of Application per Acre		Larvae Tested	Mortality		
		Mixture	DDT		After 1 Day	After 3 Days	After 5 Days[1]
	Per Cent	*Gallons*	*Pounds*	*Number*	*Per Cent*	*Per Cent*	*Per Cent*
			Series 1				
Petroleum distillate (atomizes sprays)	5.76	3	1.28	28	75	100	100
	2.88	3	.64	81	59	90	91
	1.44	3	.32	71	51	77	76
	.72	3	.16	79	28	41	45
	.576	3	.13	47	34	36	31
	.288	3	.06	68	13	16	10
	.144	3	.03	72	15	16	9
		Pounds					
Pyrophyllite dusts	4.	16	.64	170	28	88	91
	2.	16	.32	75	12	71	76
	1.	16	.16	84	5	43	55
			Series 2				
		Gallons					
Petroleum distillate (atomized sprays)	3.6	3	.8	64	84	98	100
	5.4	2	.8	60	67	95	97
	10.8[2]	1	.8	63	75	97	98
	3.6	2	.53	61	54	84	90
	3.6	1	.27	61	29	66	72
		Pounds					
Pyrophyllite dust	5.	16	.8	65	67	97	97
			Series 3				
		Gallons					
Petroleum distillate (atomized spray)	3.6	3	.8	103	80	94	98
Xylene emulsion spray	3.6	3	.8	101	59	88	97
	.72	15	.8	105	36	84	91
		Pounds					
Pyrophyllite dust	5.	16	.8	105	57	92	95
			Series 4				
Sulfur dusts:							
Fused	4.6	16	.74	67	78	99	99
Simple	4.6	16	.74	64	67	95	97
Pyrophyllite dust	5.	16	.80	59	46	91	97
Sulfur dusts:							
Fused	2.3	16	.37	67	61	97	99
Simple	1.4	16	.22	65	48	71	83
Pyrophyllite dust	2.5	16	.40	76	41	74	84

[1] Net mortality, calculated by Abbott's formula.
[2] With 10 per cent of xylene.

sions. The emulsions were prepared by dissolving DDT in a minimum of xylene, adding an emulsifier (polyethylene glycol phenylsooctyl ether) at the rate of 5 ml. per gallon of finished emulsion, and adding water to make the required volume. The petroleum-distillate spray gave a much quicker kill than the other preparations, but at the end of five days there were no important differences in effectiveness.

Simple and fused mixtures of DDT and sulfur, furnished through the cooperation of two insecticide companies, were compared with DDT-pyrophyllite mixtures in series 4 and in field-plot tests. The DDT-sulfur preparations were intended primarily for experiments on cotton flea hopper control, but were also included in the bollworm experiments.

The fused sulfur mixtures were prepared by adding melted DDT to melted sulfur and cooling and grinding the fused material. The simple mixtures were prepared by merely grinding the materials

together. Approximately 7.5 per cent of conditioning agent was added to each mixture. Arrangements were made for the preparation of a 2.5 and a 5.0 per cent DDT mixture by each process, but in the manufacturing process these exact proportions of DDT were not attained. Analysis by the Division of Insecticide Investigations, Bureau of Entomology and Plant Quarantine, showed that both 5.0 per cent mixtures actually contained were used as the diluents. The plots in each experiment were 10 rows wide and 0.1 acre in size, and were arranged in randomized blocks with 4 replications of each treatment. The dusts were applied with rotary hand guns, and the procedure and method of recording data were the same as had been previously reported (Ewing & Parencia 1943). The treatments and experimental data are shown in table 2.

Table 2.—Results of small-plot field experiments with DDT against the bollworm. Each treatment replicated 4 times.

Formulation (Per Cent DDT)	Rate of Application per Acre	Bollworm Infestation Seasonal Average		Boll Weevil Punctured Squares, Seasonal Average	Yield of Seed Cotton per Acre	
		Injured Squares	Injured Bolls		Total	Gain Over Check
	Pounds	*Per Cent*	*Per Cent*	*Per Cent*	*Pounds*	*Per Cent*
			Experiment 1			
Pyrophyllite dusts:						
10	16.5	5.4	5.1	19.0	1952	31.9
5	17.3	7.0	6.3	19.6	1816	22.7
2.5	15.3	10.2	7.8	17.0	1692	14.3
Checks:						
Cryolite-sulfur (70:30)	16.7	7.4	7.6	14.8	1726	16.6
Untreated	—	14.4	14.7	19.4	1480	—
Difference required for significance, 5% level	—	4.4	2.2	—	182	—
			Experiment 2			
Sulfur dusts:						
4.6 Fused	21.5	6.6	13.5	16.6	788	78.7
Simple	20.5	8.4	16.0	18.4	716	62.4
2.3 Fused	20.2	9.8	19.5	17.5	584	32.4
1.4 Simple	19.9	13.3	23.4	15.5	581	31.7
Pyrophyllite dust						
5	19.3	7.2	16.4	16.5	696	57.8
Untreated check	—	22.4	34.4	19.0	441	—
Difference required for significance, 5% level	—	4.0	6.0	—	101	—

4.6 per cent of DDT. The 2.5 per cent fused mixture came fairly close to specifications, since it was found to contain 2.3 per cent of DDT; but the 2.5 per cent simple mixture was found to contain only 1.4 per cent of DDT.

Each of the DDT-sulfur and the DDT-pyrophyllite mixtures gave fair to good control, the mortalities at the end of 5 days ranging from 83 to 99 per cent, the highest being slightly in favor of the fused sulfur mixtures.

Field-plot tests. Two small-plot experiments were conducted for the control of the bollworm in which various concentrations of DDT with pyrophyllite and sulfur

In experiment 1 three dust applications were made on August 3, 9, and 14. Infestation and yield records show that 5 and 10 per cent DDT gave better control of the bollworm than 2.5 per cent DDT or cryolite-sulfur. The best control and highest gain in yield were obtained from 10 per cent DDT, but statistically it was not significantly better than 5 per cent DDT.

In experiment 2 DDT-sulfur fused mixtures were compared with DDT-sulfur simple mixtures and with DDT-pyrophyllite. Three dust applications were made, on August 11, 15, and 20. There was an extremely heavy infestation of all stages of bollworm larvae when the experiment

was started. On the day before the first dust application the average number of injured squares was 40 per cent and of injured bolls 35 per cent.

The infestation records show that each dust reduced the bollworm infestation significantly below that in the untreated check. The mixtures containing 1.4 and 2.3 per cent of DDT did not give such value of several spray materials, including DDT, as compared with dusts for bollworm control. Two applications, on July 20 and 27, of DDT in xylene emulsions at rates of 0.8 and 1.6 pounds of DDT per acre-application, each application at 3 gallons per acre, gave satisfactory bollworm control. However, by August 1 it became evident that both the bollworm and the boll weevil infestations were rapidly increasing in some of the plots and that it would be necessary to change the design of the experiment in order to prevent severe losses from these insects.

Between August 3 and 25 the 36 treated acres received five applications of calcium arsenate at an average rate of 12 pounds per acre-application, and two applications of 4.6 per cent DDT-sulfur at an average rate of 20 pounds per acre-application. The combination treatment proved to be very satisfactory, and yields approaching the maximum capacity of the land were

Table 3.—Results of field-plot experiments with DDT-sulfur dusts for control of the cotton flea hopper.

Concentration of DDT	Kind of Mixture	Rate of Application per Acre	Flea Hoppers per 100 Terminals: 2 to 3 Days After Second Application[1]	Flea Hoppers per 100 Terminals: Average of 4 or 5 Weekly Records	Boll Weevil Punctured Squares, Average of 4 or 5 Weekly Records	Yield of Seed Cotton per Acre: Total	Yield of Seed Cotton per Acre: Gain Over Check
Per Cent		*Pounds*	*Number*	*Number*	*Per Cent*	*Pounds*	*Per Cent*
			Large-plot experiment 3 at Port Lavaca				
4.6	Fused	18.4	0	8.4	14.0	839	123.7
	Simple	18.0	.3	8.8	14.0	735	96.0
2.3	Fused	18.6	1.7	16.9	10.8	695	85.3
1.4	Simple	17.0	8.7	27.9	12.5	635	69.3
Check (untreated)			116.5	108.6	16.8	375	
			Large-plot experiment 4 at Port Lavaca				
4.6	Fused	13.0	0.3	4.8	6.5	1495	11.6
	Simple	14.6	0	6.5	8.8	1611	20.3
2.3	Fused	12.8	.3	7.7	7.8	1443	7.8
1.4	Simple	13.3	1.0	14.4	10.5	1307	−2.4
Check (untreated)			47.0	60.3	18.8	1339	
			Small-plot experiment 5 at Waco				
4.6	Fused	16.7	3.0	4.2	8.8		
	Simple	17.5	4.6	5.8	7.2		
2.3	Fused	17.3	3.3	5.7	9.6		
1.4	Simple	17.4	12.8	12.0	7.0		
Checks:							
Sulfur		17.9	16.0	15.9	8.4		
Untreated			27.8	25.8	8.6		
Difference required for significance, 5% level				5.8			

[1] In experiment 5, record made 4 days after first application.

good control as those containing 4.6 and 5 per cent.

Each dusted area produced significantly more seed cotton per acre than the check. Although the 4.6 per cent DDT-sulfur fused mixture resulted in the highest gain, it was not significantly higher than the 4.6 per cent simple mixture or the 5 per cent DDT-pyrophyllite.

A large-scale experiment was conducted at Waco utilizing 36 acres in the treated area and an adjoining 2 acres as a check. Originally the treated area was subdivided into several plots to determine the

obtained. The 36 treated acres averaged 1963 pounds of seed cotton per acre as compared with 844 pounds per acre in the 2 untreated acres, or a gain of 1119 pounds per acre.

COTTON FLEA HOPPER.—Two large-plot experiments were conducted at Port Lavaca and a small-plot experiment at Waco for control of the cotton flea hopper. The plots of the large-plot experiments were each 64 rows wide and ranged in size from 3.6 to 9.8 acres. The plots of the small-plot experiment were 20 rows wide, 0.2 acre in size, and were arranged in randomized blocks with 4 replications of each treatment. The small plots were dusted with rotary hand guns and the large plots with a power take-off, 8-row tractor dusting machine. The large plots were dusted twice between May 30 and June 6, and the small plots were dusted on June 29 and July 12.

The infestation records (Table 3) show that excellent control was secured from the 4.6 per cent and 2.3 per cent DDT mixtures. The control from the sulfur and from the 1.4 per cent DDT mixture was not nearly so good. In experiments 3 and 4 the infestation readings 2 to 3 days after the second application were zero or near zero in the 4.6 and 2.3 per cent DDT-sulfur mixtures, whereas in the untreated check plots they were 116.5 and 47. Averages of the 4 or 5 weekly infestation records show that the two applications gave complete seasonal control, the 4.6 per cent fused and simple mixtures averaging 8.4 and 8.8 flea hoppers. This is the most outstanding example of flea hopper control that has so far been obtained from any insecticide used in field tests.

In experiment 5 each insecticidal treatment reduced the infestation significantly below that in the check. The 4.6 per cent fused and simple mixtures and the 2.3 per cent fused mixture each gave significantly better control than the 1.4 per cent simple mixture, or the sulfur.

Yield records in experiment 3, where there was a high flea hopper infestation, indicated that the fused mixture was somewhat better than the simple mixture, but in experiment 4, where the infestation was light, this trend did not hold up, and averages of the two experiments show practically no differences in gains between the two mixtures. The 1.4 per cent simple mixture was definitely inferior to the 2.3 per cent fused mixture. No yield records were recorded for experiment 5, because the potential gains from the treatments for flea hopper control were counteracted

Table 4.—Comparative effect of DDT and other insecticides on the cotton aphid infestation in a small-plot field experiment. (Experiment 6.)

Formulation (Figures in Per Cent)	Rate of Application per Acre	Aphids per Square Inch, Average Last 4 Weekly Records	Boll Weevil Punctured Squares, Seasonal Average	Bollworm Investation		Yield of Seed Cotton per Acre	
				Injured Squares	Injured Bolls	Total	Gain Over Check
	Pounds	*Number*	*Per Cent*	*Per Cent*	*Per Cent*	*Pounds*	*Per Cent*
Calcium arsenate 50 and pyrophyllite 50	16.5	24.4	3.8	3.0	2.5	1077	−6.7
DDT 5 and pyrophyllite 95	17.4	7.5	9.2	0.5	1.3	1217	5.5
DDT 5, pyrophyllite 45, and calcium arsenate 50	16.4	35.1	4.0	2.3	0.5	1065	−7.7
DDT 5, pyrophyllite 88, nicotine dust 7[1]	17.0	1.1	9.6	.3	0	1326	14.9
DDT 5, pyrophyllite 38, calcium arsenate 50, nicotine dust 7[1]	16.4	1.0	3.3	2.8	.8	1309	13.4
Untreated check	—	1.9	14.3	1.3	6.0	1154	
Difference required for significance, 5% level	—	5.3	3.1	—	1.3	52	—

[1] Commercial nicotine dust containing 14% of soluble nicotine, making the formulation contain 1% of nicotine.

by later control measures used against the bollworm and boll weevil.

OTHER INSECTS.—Results of a small-plot field experiment to test the effect of several insecticides and mixtures on the cotton aphid, *Aphis gossypii* Glov., are shown in table 4. The plots of this experiment were 16 rows wide, 0.2 acre in size, and arranged in randomized blocks with 4 replications of each treatment. Eight dust applications were made between June 25 and August 4 at intervals of approximately 5 days.

The infestation and yield records (Table 4) show that a 1 per cent nicotine dust gave excellent aphid control, calcium arsenate caused a higher infestation than 5 per cent DDT, and a mixture of calcium arsenate and DDT caused a much higher infestation than either material alone. Laboratory and cage toxicity experiments conducted at Waco in 1945 showed that DDT is more toxic to some of the common aphid predators than is calcium arsenate. Thus, it is indicated that a combination of the two materials has a wider range of high toxicity to the more important aphid predators than has either used alone, and also that there are factors other than the reduction of predators involved in increased aphid populations following the use of calcium arsenate on cotton (Dunnam and Clark 1941).

Boll weevil infestation records were made in the six field-plot experiments reported in this paper, as shown in tables 2, 3, and 4. These experiments contained 36 plots treated with 4.6 or 5 per cent DDT in sulfur or pyrophyllite and dusted an average of three times at the rate of 17.3 pounds per acre-application. In the DDT-dusted plots the boll weevil punctured squares averaged 12.6 per cent as compared with 16.2 per cent in the untreated check plots, or 22.2 per cent control. Immediately following two to four dust applications of 5 per cent DDT-pyrophyllite in three large-scale experiments at Waco, the average boll weevil infestation was 39.3 per cent of punctured squares in the dusted plots and 47.2 per cent in the untreated checks. Under these heavier infestations the control from DDT was only 16.7 per cent. The boll weevil control secured in 1945 field-plot experiments is in line with previously reported cage tests at Waco by Ivy (1944), which showed 18.5 per cent net mortality, and at Tallulah, La., by Smith (1944), which showed 16 per cent net mortality. These experiments show definitely that DDT does not give adequate or satisfactory boll weevil control.

The red spider *Tetranychus sp.* increased rapidly in experiment 6 following the use of DDT. This mite became particularly noticeable after the sixth application, and the infestation approached the damage point immediately after the eighth application. The infestation was severe in each plot receiving DDT, and negligible, or at least not noticeable, in the untreated check plots and in the plots treated with calcium arsenate alone. There was no red spider build-up or damage in any experiment at Waco or Port Lavaca where DDT-sulfur mixtures were used. While it is believed that the presence of sulfur in the mixture will control the red spider, still it should be recalled that none of the DDT-sulfur mixtures were applied as many as eight times.

SUMMARY.—Cage experiments conducted at Waco, Tex., during 1945 showed that DDT in atomized Diesel-oil sprays gave a quicker kill of bollworms, *Heliothis armigera* (Hbn.), than did DDT-pyrophyllite dusts, but there were no important differences at the end of the standard 5-day test period. Diesel-oil sprays, when properly atomized and distributed over the plant, caused discernible injury to cotton plants in only one instance, namely, during a period of extremely high humidity.

In field-plot experiments both 5 and 10 per cent DDT gave better bollworm control then 2.5 per cent DDT or cryolite-sulfur.

Fused DDT-sulfur dusts were tested against the cotton flea hopper *Psallus seriatus* (Reut.) in field-plot experiments and against the bolloworm in cage and field-plot experiments. There were no significant differences between the fused and the simple, or mechanical, mixtures in any of the experiments, but in most of the experiments the control obtained, or yields secured, or both, were slightly in favor of the fused mixtures. The 4.6 per cent DDT-sulfur mixtures gave the most outstanding flea hopper control ever obtained in field experiments. In one large-plot experiment two applications gave seasonal control, the average infestation for 5 weeks in the dusted plots being 8.6

flea hoppers per 100 terminals as compared with 108.6 in the adjoining untreated check.

In a field-plot experiment the addition of 1 per cent nicotine to DDT mixtures gave satisfactory control of the cotton aphid, *Aphis gossypii* Glov. Aphid build-up was greater following use of a DDT-calcium arsenate mixture than following use of either material alone.

Infestation records made in the various field-plot experiments showed that DDT does not give satisfactory control of the boll weevil, *Anthonomus grandis* Boh. In one experiment 6 applications of DDT caused marked increases in populations of the red spider *Tetranychus sp.*

A large-scale experiment conducted at Waco for maximum combination control of bollworm and boll weevil, using DDT-sulfur mixture and calcium arsenate produced an average of 1963 pounds of seed cotton per acre on 36 treated acres and an average of 844 pounds per acre on two adjoining untreated acres, or a gain of 1119 pounds per acre.—3-1-46.

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Damage by *Euschistus impictiventris* and *Chlorochroa sayi* to Sugar Beets Grown for Seed

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Investigations commenced in 1938 by the Bureau of Entomology and Plant Quarantine on insects affecting sugar beets grown for seed have shown that several species of hemipterous insects which frequent seed-beet fields in the srping in Arizona, New Mexico, and southern California are capable of damaging the beet-seed crop. Cage studies begun in 1938 (Hills 1941, 1943) showed that lygus bugs and certain of the stinkbugs, *viz.* the Say stinkbug, *Chlorochroa sayi* Stål, and the red-shouldered stinkbug, *Thyanta custator* (F.), were responsible for a reduction in the percentage of viable seed produced. Insect-population studies in sugar beets grown for seed have shown that another of the stinkbugs, the brown cotton bug, *Euschistus impictiventris* Stål, is present in the fields each year, although populations thus far have never been known to be high. In 1944, therefore, a field-cage experiment was set up to determine the damage to the beet-seed crop attributable to the brown cotton bug and to compare the damage caused by this stinkbug with that due to the Say stinkbug.

METHODS AND ARRANGEMENT.—The cages employed for this work were similar to those used in previous experiments of this type and consisted primarily of a cloth tube approximately 2 feet in diameter and 4 feet tall, held extended between two stakes by wire hoops. The cage covering was made of curtain scrim having approximately 16 meshes per linear inch, and each cage enclosed a single beet spike, the bottom of the cage being gathered and tied around the spike approximately 18 inches above the ground. Sixty cages were arranged in the field in randomized blocks of 3 treatments replicated 20 times. Each block consisted of one cage containing *Euschistus impictiventris*, one cage containing *Chlorochroa sayi*, and one cage insect-free. The cages were placed over the seed-beet plants on April 21 and 22, at which time the plants had seed stalks approximately 30 inches tall and were approaching the preblossom stage of de-

velopment. The stinkbugs, however, were not introduced into the cages until the first week in May, just as the plants were entering the flowering stage. Figure 1 shows the cages as they appeared in the field on June 1.

FIG. 1.—Field cages for determining the comparative damage of *Chlorochroa sayi* and *Euschistus impictiventris* to sugar beets. Photographed on June 1, approximately 3 weeks before harvest.

The stinkbugs used for this work were young adults from colony cages in the field. During the fall of 1943 the parent adults were gathered in the field and placed in cloth-covered colony cages 4 by 5 by 7 feet (Fig. 2). In the late winter and early spring specimens from these cages were brought into the laboratory, where they were placed in small cylindrical screen-wire cages (approximately $3\frac{1}{2}$ by 7 in.) within a carrying cabinet and held at a constant temperature of approximately 82° F. Branches of wild host plants, either *Chenopodium murale* L. or *Sisymbrium irio* L., were placed in the cages as food. Since in confinement these insects tend to oviposit on a cloth surface, cloth strips were placed within the cages and most of the eggs were deposited in masses on these strips, a practice which greatly facilitated handling. Egg masses were removed from the cages daily by cutting out small pieces of cloth to which they were attached. These were then put into test tubes, and placed in the cabinet for incubation. In a few days after the eggs had hatched, the young nymphs were placed in half-pint fruit jars, and each day were given fresh pods of *S. irio* for food. Nymphs in the third to fifth instars were released into colony cages in the field.

Between May 3 and May 6, 3 males and 3 females of *Euschistus impictiventris* and a like number of *Chlorochroa sayi* were placed in each cage assigned to the respective insects. Twenty adult lady beetles were also put into each of the 60 cages to prevent aphid infestations. The cages were examined from time to time, and any dead stinkbugs found in the cages were replaced with live specimens of the same sex. Insects in the cages at the end of the experiment were counted to check on reproduction. The number of *E. impictiventris* per cage averaged 15.8 and of *C. sayi* 18.2. These figures indicate a slight bias, but probably not enough to be of any great significance. Two of the blocks were discarded because of extreme differences in numbers of insects recovered, and the results were based on 18 replicates.

At maturity (late June) the seed in each cage was harvested, cleaned, and analyzed separately. Threshing was accomplished by hand stripping and cleaning by means of a small hand-operated mill over a screen. The mill was so constructed that the lighter seed, ordinarily blown out with the trash, was automatically separated from the still lighter leaves and sticks. This

FIG. 2.—Colony cages from which specimens were taken for introduction into cages shown in figure 1.

air-separated seed was saved, and the yield and viability were determined. Inasmuch as this seed would ordinarily be lost in the commercial cleaning operation, an increase in the percentage of air-separated seed would represent a loss in yield. Moreover, the viability of the seed is of relatively little economic importance, but does contribute to a more complete understanding of the injury caused by these stinkbugs. The air-separated seed from

Table 1.—Yield and viability of sugar beet seed balls produced in cages containing *Chlorochroa sayi* and *Euschistus impictiventris*. Phoenix, Arizona, 1944.

Insect	Marketable Seed Balls (18 Cages)				Air-Separated Seed Balls (17 Cages)	
	Mean yield per cage (grams)	Per cent viable		Number of sprouts per viable ball	Mean yield per cage (grams)	Per cent viable (germination test)
		Germination test	Crack test			
E. impictiventris	100.4	70.6	89.8	1.70	1.5	23.0
C. sayi	101.6	61.8	82.1	1.49	1.8	7.9
Insect-free (check)	104.8	88.5	95.6	2.04	0.8	26.6
Difference required for significance ($P=0.05$)	[1]	11.9	8.1	0.17	[1]	12.4

[1] Not significant by the F test.

one cage was lost in cleaning; thus it was necessary to discard these data for that block. The data for air-separated seed are based on 17 replicates. The viability of the seed was determined by germination tests made by placing them between moist blotters according to the rules and recommendations for testing seed established by the Department of Agriculture (U. S. Bur. Plant Indus. 1938), and by the crack test, which consisted in cracking the seed balls against a hard surface with a hammer, the appearance of starch being taken as an indication of viability.

DISCUSSION.—Results of the analyses of the seed produced in this experiment are given in table 1. Germination data for marketable seed show that both *Euschistus impictiventris* and *Chlorochroa sayi* caused a significant reduction in the percentage of viable seed balls produced. By both the germination test and the crack test there was a tendency for *C. sayi* to reduce seed viability more than *E. impictiventris*, although these differences were not mathematically significant. Both insects caused a reduction in the number of sprouts per viable seed ball, and *C. sayi* caused the greater reduction.

Germination tests on the air-separated seed showed a definite decrease in the percentage of viable seed produced in the *Chlorochroa sayi* cages under that produced in the insect-free cages and in the *Euschistus impictiventris* cages.

There were no appreciable differences in the quantity of either air-separated seed or marketable seed produced in any of the cages.

SUMMARY.—In 1944 field-cage studies were conducted to determine the effect of the stinkbug *Euschistus impictiventris* Stål. on the beet seed crop, and to compare the damage caused by this insect with that caused by *Chlorochroa sayi* Stål. Both insects caused a reduction in the percentage of viable seed balls produced, as well as in the number of sprouts per viable seed ball. Indications were that *C. sayi* has a tendency to cause slightly more damage than *E. impictiventris*.—3-1-46.

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Ecological Effects of an Aphid Population Upon Weight Gains of Tomato Plants[1]

FENTON T. WEST

The ecological relationships of sap-feeding parasitic insects and their host plants are exceedingly complex. The tests reported here were intended to determine some of the effects of an aphid population upon their host plants. All of the data given were accumulated by using seedling tomato plants and the potato aphid, *Macrosiphum solanifolii* Ashmead.

It seemed probable that the effects of an insect population upon the host plant could be more carefully determined in the case of an insect that lives directly upon the sap of the plant rather than with an insect that consumes the solid tissues. The potato aphid, has a number of characteristics that make it a desirable laboratory test insect and it thrives on the tomato, which is easily grown in nutrient solution. This combination was therefore chosen for these two series of tests. This combination has the one fault that aphids do not reproduce well at high temperatures most favorable for the growth of tomato plants, but if day temperatures do not go above 80 degrees F. and the aphids are cooled to 40 degrees F. or lower for a few hours each 24-hour period, both the host plant and the parasites grow quite well.

The feeding of an insect population affects more or less adversely the nutritive functions of the host plant, and tomato plants show aphid injury in a number of ways such as downward curling of the leaves, reduction of leaf area, diminution of the stem, elongation with paucity of the root system. At higher infestations the plants wilt, fail to recover turgidity, and finally die. Since all of these characteristics merge and overlap and are difficult to describe objectively the effect of the aphid population upon the multiple weight gains of the plants was taken as that single objective and representative factor that could be measured accurately and quantitatively. The use of hydroponic solutions and gravel in growing the plants made it possible to determine the weight of the entire plant at both the beginning and the end of the experimental period, the gain in weight, and the multiple weight gain based upon the initial weight. Inasmuch as the plants in these tests were small and varied only slightly in initial weight, a comparison of the multiple weight gains seems a most logical basis for estimating insect injury.

The nature and extent of the effects and responses of the host plant to its parasitic aphid population can be investigated more exactly when the plants are grown in nutrient solutions rather than in soil.

Arnon & Hoagland (1944) have pointed out that an important development in methods of investigating problems involving the nutrition of the plant consists in "substituting an artificial and controllable root medium for the complex and heterogeneous natural medium of a soil." Since it seemed desirable to reduce to a minimum the variable and uncontrollable factors involved in an investigation of the complex relationships of host plant and the parasitic aphid population, all of the tests were performed with plants growing in nutrient solutions. Certainly by this means the variations in the root environments from one plant to another were reduced to a minimum.

CULTURE POTS AND GRAVEL.—During the test period, the experimental host plants were grown in silicon quartz sand in white glazed earthenware pots made on special order. These pots, had a seven-eighths inch hole at the base to permit complete drainage, were 5.5 inches deep and 5.5 inches in diameter and had a capacity of one-half gallon. They were fitted with No. 3 stoppers having a three-sixteenths inch hole, and glass tubing of suitable length to drain the pots into one or more vessels. When necessary the glass drain pipes were covered or painted black to prevent the growth of algae and consequent clogging.

A mixture of insoluble silicon quartz sand and gravel was used in the pots around the roots of the plants. The sand-gravel mixture provided mechanical support for the plants and a properly aerated solution medium for the roots. The sand-

[1] The data contained herein is a portion of that given in the doctor's dissertation presented in partial fulfillment of the requirements for the Ph.D. degree in Entomology at Ohio State University in June 1945.

gravel particles varied from a sixteenth to a half inch in diameter, with approximately 80 per cent of the grains being one-fourth inch or less in diameter.

Before being used, the gravel was washed thoroughly, allowed to drain and then rinsed five times with the appropriate solution. No attempt was made to determine the amounts of soluble nutrients that became available from the gravel when the nutrient solutions were added to it.

CULTURING AND TRANSFERRING THE PLANTS.—The plants used in the two series of experiments were started from seed in flats of soil or sand. The soil had previously been treated with formaldehyde to prevent the growth of damping-off fungus, and the seeds were treated with red copper oxide at the time of seeding.

As soon as the secondary leaves were two to three centimeters in length, the plants were transplanted to 2.5-inch pots of soil in which they were allowed to grow until they had attained sufficient size for experimental use. By the time the plants had attained a height of 5 to 8 centimeters from ground level to tip of the central bud, a strong root system had been formed. As may be noted from tables 1 and 2, the weights of the plants varied from 1.4 to 4.5 grams at the time they were transferred to the experimental pots.

A method of transferring the plants was devised to cause a minimum of damage to the root system. The soil in the 2.5-inch pots was moistened with solution and the plant with the soil was removed by tapping the inverted pot lightly. With the top of the plant kept dry, the root system was immersed in solution and the soil dropped away from the roots, leaving an intact root system. Excess solution was blotted from the roots with facial tissue and the plants weighed to the nearest tenth of a gram.

After a test plant had been weighed it was placed in position in a pot partly filled with solution. When in the solution, the roots separated out and if sand and gravel were lightly sprinkled into the pot until full the roots were caught and held in a nearly normal distribution. Each plant was then assigned a number and allowed to drain. Since preliminary tests had shown that heavy infestations of aphids on the plants at the time of transfer prevented the rapid formation of roots in the new situation, a two-day period was allowed for the plants to become established before they were infested with an aphid population.

At the termination of a series of experiments, the pots were immersed in succession in a wooden tub partly filled with tap water. By rotating the pot in a diagonal position in the water it was possible to wash away the sand and gravel and remove the plant with the root system practically intact. Excess water was blotted from the roots and the plants again weighed to the nearest tenth of a gram. The initial and final plant weights are recorded in tables 1 and 2.

PREPARATION AND USE OF THE PLANT NUTRIENT SOLUTIONS.—Throughout these experiments the plant nutrient solutions used were those suggested by Hoagland & Arnon for the growing of plants in nutrient solution. Molar stock solutions were prepared as indicated below from chemically pure salts and the amounts indicated were used in making a complete solution.

FORMULA AND NAME	CC. PER LITER
KH_2PO_4, potassium acid phosphate	1
KNO_3, potassium nitrate	5
$Ca(NO_3)_2$, calcium nitrate	5
$MgSO_4$, magnesium sulfate	2

To each liter of the solution thus prepared was added one cc. of a supplementary solution prepared as follows:

COMPOUND	GRAMS PER LITER OF H_2O
H_3BO_3, boric acid	2.86
$MnCl_2 \cdot 4H_2O$, manganese chloride	1.81
$ZnSO_4 \cdot 7H_2O$, zinc sulfate	0.22
$CuSO_4 \cdot 5H_2O$, copper sulfate	0.08
$H_2MoO_4 \cdot H_2O$, molybdic acid (assaying 85% MoO_3)	0.02

According to Hoagland & Arnon, 1938, adding 1 cc. of this solution to each liter of nutrient solution will give the following concentrations of the designated rare elements:

ELEMENT	PARTS PER MILLION
Boron	0.5
Manganese	0.5
Zinc	0.05
Copper	0.02
Molybdenum	0.01

Table 1.—Series I.

Plant No.	Plant Weights		Gain in Weight	Gain Per Gram of Original Weight	Infestation	
	Initial	Final			Initial	Final
1	4.5	130.8	126.3	28.0	50	945
2	4.2	118.7	114.5	27.2	150	1,535
3	3.2	111.0	107.8	33.6		
4	3.2	126.4	123.2	38.5		
5	3.0	120.8	117.8	39.3		
6	3.0	78.2	75.2	25.0	50	1,111
7	3.0	77.4	74.4	24.8	150	2,401
8	2.8	108.0	105.2	37.5		
9	2.7	91.4	88.7	32.8	50	1,241
10	2.7	88.5	85.8	31.4	150	1,421
11	2.3	97.8	95.5	41.5		
12	2.3	115.3	113.0	49.1		
13	2.4	50.4	48.0	20.0	150	2,468
14	2.2	118.6	116.4	52.6		
15	2.0	71.8	69.8	34.9	50	1,919
16	1.4	76.0	74.6	53.3		
17	2.7	79.4	76.7	28.4		
18	2.2	69.5	67.3	30.5	50	1,160
19	2.5	76.1	73.6	29.4		
20	3.8	53.2	49.4	13.0	150	2,105
					1000	16,306

SERIES I — MISCELLANEOUS DATA

Date plants were started on complete solution	April 14
Date infested with aphids	April 17
Number of days aphids were on the plants	21 days
Series concluded—final weights recorded	May 8
Total initial weight of ten non-infested plants in grams	25.6
Total initial weight of ten infested plants in grams	30.5
Average gain in weight per gram of initial weight	
1. Infested with 50 aphids	30.24 grams
2. Infested with 150 aphids	23.28 grams
3. Non-infested	40.32 grams
Total gain in weight of	
5 plants infested with 50 aphids each	427.30 grams
5 plants infested with 150 aphids each	372.10 grams
10 plants non-infested	501.90 grams

These concentrated or stock solutions were made with water double-distilled in block tin, and then stored in 6-liter bottles in the semi-darkness of a basement. From time to time, as needed, 19 liters of the usable (dilute) complete solution were prepared in 5-liter carboys with distilled water and the appropriate amount of the stock solutions as determined from the table given above. The pH of the dilute solution thus obtained was determined and adjusted to about 6.5 by the addition of the appropriate amount of sulphuric acid or sodium hydroxide. Phenol red and brom cresol green were used as indicators in making the titrations. No attempt was made to prevent or control change in the pH of the solution brought about by the action of the plants except to use relatively large or excessive amounts of the solution and to add fresh solution to that used previously and which had drained from the pots.

Temperature and Humidity.—These tests were conducted in a small greenhouse constructed as an adjunct to the writer's home. The greenhouse was heated by means of a gravity flow hot water system, with the gas heated and thermostatically controlled heating coils located in the house basement. Night temperatures were usually about 40° F. and day temperatures were kept above 76° F. and seldom went above 80° F. Humidity at night approximated 100 and was kept above 50 during the day.

Production and Use of Aphids.—These two sets of tests were conducted with offspring produced parthenogenetically from a few females chosen from a single field infestation; hence, it is probable that all the individuals used were genetically similar. In addition, adults of the same age (differing in age from oldest to youngest not more than 48 hours) were used to infest the plants at the beginning

Table 2.—Series II.

Plant No.	Plant Weights		Weight Gain	Weight Gain Per Gram of Initial Wt.	Infestation	
	Initial	Final			Initial (Effective adults)	Final (Nymphs)
1	3.5	40.6	37.1	10.60	109	1,509
2	2.2	53.3	50.1	15.65		
3	2.7	36.0	33.3	12.37		
4	2.5	16.6	14.1	5.64	90	811
5	2.5	29.1	26.6	10.64		
6	2.5	18.6	16.1	6.44	84	944
7	2.5	31.6	29.1	10.84		
8	2.4	23.7	21.3	8.87	93	926
9	2.4	11.2	7.8	4.66	108	1,222
10	2.3	36.0	33.7	14.65		
11	2.2	33.2	31.0	14.09		
12	2.3	45.0	42.7	18.56	84	616
13	1.8	26.7	24.9	13.83		
14	2.1	9.2	8.1	3.38	66	640
15	2.0	23.7	21.7	10.85		
16	2.0	22.5	20.5	10.25	59	566
17	1.9	25.5	23.6	12.42		
18	2.0	9.0	7.0	3.50	82	812
19	1.8	26.7	24.9	13.27		
20	1.8	17.7	15.9	8.83	76	848
Total infested	23.5	214.1	190.6	8.11 Ave.	851	8,894
Total non-infested	22.9	321.8	298.9	13.05 Ave.		

SERIES II MISCELLANEOUS DATA

Date plants were started on complete solution	May 9
Date infested with aphids	May 11
Number of days adults were on the plants	6 days
Number of additional days nymphs were on plants	6 days
Series concluded—final weights recorded	May 23
Total initial weight of ten non-infested plants	22.9 grams
Total initial weight of ten infested plants	23.5 grams
Weight gain per gram of initial weight—non-infested, average	13.05
Weight gain per gram of initial weight—infested, average	8.11

of a series of tests. The large numbers needed for making the infestations were obtained by transferring numerous reproducing adults to aphid-free plants and at the end of a 48-hour period removing the adults with an aspirator. When this age-limited group of nymphs were about to undergo their third ecdysis they were transferred by the use of a camel's hair brush to the test plants.

In making the transfers to the test plants, the nymphs from a single adult or a group of adults were scattered by one or two over the entire group of test plants in order to assure complete randomization of the parasitic aphids.

PROCEDURE IN EACH OF THE SERIES.—*Series I.* The initial weight of the plants was determined at the time of transferring them to the test pots. These plants were then given 3 days to become established. With the plants arranged by weight in groups of four, two plants in each group were infested with aphids—one plant with 50 and the other with 150 aphids. At the end of 21 days an accurate count was taken of the number of nymphs that had been produced on each plant and the final weights of the plants were determined by the manner previously described. All of these data are given in table 1.

Series II. In this series the plants were paired by weight at the beginning of the test period and allowed two days to become established, after which one plant of each pair was infested with 115 preadult aphids, and at the conclusion of the sixth day thereafter the adults present were removed, counted, and listed as "Initial Infestation—Effective Adults." At the end of the twelfth day after initial infestation, the nymphs on each plant were counted, the plants weighed as previously described and the experiment concluded. All of these data appear in table 2. Certain other data concerning the series

are included under the heading "Miscellaneous Data."

RESULTS AND CALCULATIONS.—*Series I.* If the weight gains per gram of initial weight of the infested and non-infested plants are grouped the following analysis of variance of the data is obtained:

Table 3.—Weight gains of infested and non-infested plants.

SOURCE OF VARIATION	DEGREES OF FREEDOM	MEAN *d*	SUM OF SQUARES	POOLED VARIANCE	*s*
Infested	9	26.7	382.00		
Non-infested	9	40.3	716.56		
Sum	18	13.6	1098.56	8.07	2.8

The multiple weight gains of infested plants was reduced by 33.7 per cent as compared with the non-infested plant weight gains.

If a similar grouping of the weight gains of those plants infested lightly (50 aphids) and heavily (150 aphids) is made these data may be tested for significance to give the data shown in Table 4.

The reduction in weight gain calculated on the basis of non-infested and low-infested plant weight gains was 24.9 per cent, while a comparison of non-infested and highly-infested plant weight gains showed a reduction of 42 per cent.

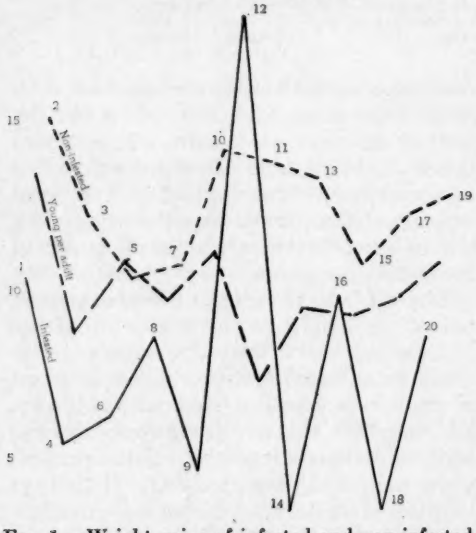

FIG. 1.—Weight gains of infested and non-infested plants. Twenty minutes were paired by weight and one plant of each pair was infested heavily. The graph below shows the results as reflected by weight gains per gram of initial plant weight. The aphid reproductive rate on each of the 10 plants is also given. The data for this graph were taken from tables 1 and 2.

Table 4.—Analysis of variance—high and low infestation.

SOURCE OF VARIATION	WEIGHT GAIN, *d*	DEGREES OF FREEDOM	SUM OF SQUARES	POOLED VARIANCE	*s*
50 aphids	30.24	4	56.6920		
150 aphids	23.28	4	199.0480	31.98	5.65
Sum	6.96	8	255.7400		

Series II. The data on weight gains per gram of initial weight in table 2, which are represented graphically in figure 1 show (with one exception, Plant No. 12) the great reduction in the weight gains brought about by the parasitic aphid population. The growth conditions of the 10 infested plants were at optimum except for the aphid infestation. Each gram of infested plant tissue carried 3.62 adults and their offspring for a 6-day period and 37.8 nymphs for an additional 6 days. The 10 infested plants with an initial weight of 23.5 grams gained only 190.6 grams in 14 days, whereas the 10 non-infested plants weighing 22.9 grams gained 298.9 grams during the same period.

Two plants of this series were chosen

FIG. 2.—Above, Plant No. 9, Series II; Below Plant No. 10, Series II.

as typical of the results. Plant No. 9, (Fig. 2, above) carrying a population of 1,222 nymphs and with an initial weight of 2.4 grams attained a weight of 11.2 grams or 4.66 times its initial weight. By way of contrast, Plant No. 10 (Fig. 2, below) with an initial weight of 2.3 grams during the same time attained a weight of 36.0 grams or 14.7 times its initial weight. The photographs of the two plants, taken at the conclusion of the test period, show by contrast how greatly the growth, nutrition and normal appearance of the infested plants were changed by the parasites. It should be noted that the infested plant was photographed natural size while the non-infested plant was photographed at one-half natural size.

Table 5.—Analysis of variance—effects of aphid population upon plant growth.

Source of Variation	Deg. of Freedom	Sum of Squares	Mean Square
Discrepance (error)	9	49.040	5.449
Plots	9	116.150	12.905
Treatments (aphids)	1	114.624	114.624
Total	19	279.814	

$s = Sx^2/n - 1 = 98.09/9 = 10.89 = 3.30$ grams

$F = 114.624/5.449 = 21.03$. This value is significantly higher on the 1% level than 10.56, the F-value for a df of 1 and 9.

The root systems of the infested plants also showed the adverse effects of the aphid population. Paucity and sparseness of laterals were most pronounced, creating an impression of excessive elongation of the initial root system.

An analysis of variance, using sums and differences, as suggested by Snedecor is perhaps the best method of testing the significance of the data obtained in Series II. The paired weight gains per gram of initial weight are used as the basis and the completed calculations are shown in table 5.

CONCLUSIONS.—It has been shown that 40 or more aphids per gram of plant tissue constitutes a heavy or critical infestation that affects significantly the metabolism and growth of host tomato plants, even when conditions for plant growth are optimum. In Series I a significant reduction in weight gains of host plants of 13.6 grams per gram of initial weight was brought about by a heavy infestation of aphids. A population of 1,000 adults and 16,306 nymphs on 53.52 grams of initial weight of plant tissue caused a reduction in the final weight of 33.7 per cent with the non-infested plants used as a base. On this same basis, weight gains of the heavily infested plants were reduced by 42.2 per cent. Statistical analysis of the raw data have shown these reductions to be highly significant.

In the tests of Series II it was demonstrated that 40 6-day-old nymphs per gram of initial weight of host plant tissue constituted a critical infestation and reduced the multiple weight gains of the infested plants by at least 38 per cent when compared to the non-infested plants as a base. Statistical analysis showed that the differences in the raw data were highly significant and that the data could not have been drawn by chance from the same population.—9-20-45.

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A STITCH IN TIME

Professor A. H. MacAndrews accompanied by a plant pathologist, is making an inspection of the trees on the historic sites in the State of New York on behalf of the State College of Forestry at Syracuse University. The object is to determine whether the trees are suffering from attacks of insects or fungi and to recommend appropriate treatment. Their example may well be followed elsewhere.

Insecticides Applied to Forest Litter to Control New Guinea Chiggers[1]

RAYMOND C. BUSHLAND[2,3]

In parts of the Pacific where our troops encountered scrub typhus, an important means of preventing infection was the clearing of campsites to expose the ground to the drying effects of sunlight and thus destroy the chigger vectors. Blake *et al.* (1945) reported that, among troops occupying kunai grass flats, the risk of infection was greatest during the first week in a new area and that after the fourth or fifth week a campsite ceased to be dangerous.

The rate at which various areas could be freed of chiggers by clearing depended upon such factors as weather, nature of terrain and availability of labor and equipment, but, even under most favorable circumstances, environmental control measures were slow.

Chittenden (1915) recommended dusting sulfur at the rate of 50 pounds per acre to control American chiggers. Smith & Gouck (1944) made comparative tests in Georgia using sulfur, DDT and certain other insecticides and obtained "satisfactory control" of *Acariscus masoni* and *Eutrombicula alfreddugesi* with applications of 57 pounds per acre of sulfur. In their tests DDT, applied as a 2 per cent dust at 32 pounds per acre or as a 1 per cent dust at 125 pounds per acre, was about as effective as sulfur. Diphenylamine caused a considerable reduction of chiggers but was less effective.

TEST MATERIALS.—Sulfur was not available in New Guinea but large amounts of DDT had been sent to the Pacific theater for mosquito and fly control. Therefore, special attention was given to testing DDT. A supply of diphenylamine and diphenylene oxide was on hand for tests of clothing treatments, and as these compounds were very toxic to mites crawling on impregnated clothing (Bushland 1946) they were tested in comparison with DDT.

A preliminary series of tests was made with the compounds as 5 per cent solutions in diesel oil applied as sprays to the ground surface. These solutions were compared with equivalent amounts of plain diesel oil.

No DDT dusts were available and the only diluent readily obtainable was very finely powdered calcium carbonate. A 5 per cent dust was made by dissolving DDT in acetone and mixing it into a paste with calcium carbonate. After drying, the mixture was ground through a sieve to a fine powder. This mixture was tested in comparison with plain calcium carbonate.

THE TEST AREA.—The area selected for the tests was a section of rain forest in the foothills of the Cyclops Mountains near Hollandia, Dutch New Guinea. The tree cover was sufficiently dense that but little sunlight penetrated to the forest floor, which was covered with decaying leaves. Patches of ferns provided ground cover in some spots.

Schongastia pusilla Womersley and *S. blestowei* Gunther were about equally abundant in this area. These larval mites crawled rapidly on the shoes of an observer standing in an infested spot. The mite population was not uniformly distributed. In one spot chiggers might crawl on one's shoes at a rate of 3 or 4 per minute while in a seemingly identical environment only a few feet away no mites could be found.

Test plots measuring 20 by 20 feet were marked off in the most heavily infested parts of the area. The plots were selected not only for abundance of mites but also for accessibility and ease of treatment. Places littered with fallen branches or tangled with ferns were avoided. It was therefore possible to apply sprays and dusts quite uniformly over the litter of decomposing leaves which harbored the mites.

The mite population was estimated by the "boot-count" method developed by Major R. N. McCulloch of the Australian Army. The observer crouched in one spot for five minutes and captured and counted the chiggers as they crawled on his shoes. Six observations were made in each plot

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[3] Acknowledgment is made of the assistance of Sergeants L. A. Griffis, John Cannon and H. H. Harris of the Third Medical Laboratory.

and at control points adjacent to the plots. These counts were made immediately before treatments were applied and at intervals thereafter. Samples of mites taken in boot counts were saved for determination. Both species were represented in collections made after the treatments were applied.

During the period covered by these tests the daily mean temperature averaged about 80° F. Rain fell several times weekly and the ground was always damp.

Although rains were frequent and heavy there was no observable washing-away of the treatments. The test plots were located on gently sloping ground and the porous leaf mold and sandy subsoil let the rain soak into the ground rather than run off.

TESTS OF SPRAYS.—Plots were sprayed using a Chemical Warfare Service "decontaminating apparatus" (a three-gallon pressure sprayer commonly used in malaria control), using the nozzle that produced the finer spray. Preliminary trials indicated that with the equipment employed it was necessary to spray at a rate of 40 gallons per acre to obtain complete coverage. In spots covered by ferns the nozzle was held below the fronds to assure that the spray reached the ground.

In the tests of miticides as 5.0 per cent solutions in diesel oil, those containing diphenylamine and diphenylene oxide were applied at the rate of 80 gallons per acre. The DDT solution was used at 40 and 80 gallons per acre and diesel oil alone was tested at 40, 80 and 160 gallons per acre.

The findings of these tests have been summarized in table 1.

It will be noted in part "A" of table 1 that on the day after treatment no mites were found in the plots sprayed with diesel oil or the DDT solution at rates of 40 and 80 gallons per acre. Nine days after treatment mites were again active in all plots. The population in each plot, as indicated by "boot-counts" was about one-third as great as the original. When the most heavily treated plots were examined after 32 days mites were almost as numerous as they were before the plots were treated.

The plots were not examined until

Table 1.—A summary of observations on mite activity in plots treated with various spray applications. (Figures represent the average number and range in number of mites found in six five-minute observation periods at each examination.)

A. Sprays applied May 1, 1945
Treatment and rate of application

	5% DDT IN DIESEL OIL				DIESEL OIL				CONTROL	
	40 gals. per A		80 gals. per A		40 gals. per A		80 gals. per A		No Treatment	
TIME OF EXAMINATION	*Av.*	*Range*	*Av.*	*Range*	*Av.*	*Range*	*Av.*	*Range*	*Av.*	*Range*
Before treatment	9.3	7–15	10.2	7–14	7.0	2–12	9.7	6–13	8.7	3–20
After one day	0.0	—	0.0	—	0.0	—	0.0	—	7.4	4–12
After 9 days	3.7	0–7	3.8	1–10	2.8	0–9	2.3	1–5	12.8	9–16
After 32 days	—	—	7.2	3–10	—	—	8.3	5–14	13.0	6–23

B. Sprays applied May 30, 1945
Treatment and rate of application

	5% DIPHENYLAMINE (in diesel oil)		5% DIPHENYLENE (in diesel oil)		DIESEL OIL				CONTROL	
	80 gals. per A		80 gals. per A		80 gals. per A		160 gals. per A		No Treatment	
TIME OF EXAMINATION	*Av.*	*Range*	*Av.*	*Range*	*Av.*	*Range*	*Av.*	*Range*	*Av.*	*Range*
Before treatment	19.3	10–27	16.7	9–21	14.5	5–23	13.5	7–19	13.0	7–25
After 3 days	0.2	0–1	1.2	0–5	1.0	0–3	0.7	0–3	17.0	10–27
After 6 days	1.5	0–5	2.2	0–7	1.7	0–6	0.8	0–2	11.2	6–19
After 9 days	2.0	0–4	2.2	0–5	3.8	0–9	2.5	0–4	8.5	6 11
After 14 days	5.0	0–15	5.2	2–9	5.0	3–12	3.8	1–6	9.8	4–16

three days after treatment in the tests summarized in part "B" of the table. Mite activity was greatly reduced in all the treated plots but at least one mite was found in each. Six days after treatment mites were more numerous in all the treated plots: "boot-counts" averaged about 10 per cent of those recorded before treatment. There was only a slight increase in mite activity in the next three days. When final observations were made 14 days after treatment, the mite population in each of the treated plots was indicated to have increased to approximately one-third of that existing before treatment.

Where mites were numerous there was a great variation in the number of chiggers found crawling on the shoes. This variation is well illustrated by the range of six "boot-counts" in each plot when observations were made before treatment. Because of the extreme range within plots the differences between treatments cannot be considered significant.

Table 2.—A summary of observations on mite activity in plots treated with dusts at a rate of 320 pounds per acre. (Figures represent the average number and range in number of mites found in 6 five-minute observation periods at each examination.)

Time of Examination	5% DDT in $CaCO_3$		Control $CaCO_3$		Control No Treatment	
	Av.	*Range*	*Av.*	*Range*	*Av.*	*Range*
A. Dust applied June 22, 1945						
Before treatment	9.5	0–21	7.2	4–11	11.3	4–16
After 3 days	0.8	0–3	7.3	0–22	13.0	7–24
After 5 days	1.0	0–3	3.3	0–8	5.8	0–15
After 12 days	2.8	1–7	—	—	10.7	1–23
B. Dust applied June 26, 1945						
Before treatment	6.7	4–9			7.8	5–17
After 1 day	1.0	0–3			5.8	0–15
After 8 days	2.8	0–7			10.7	1–23

TESTS WITH DUSTS.—DDT was tested as a dust at 5.0 per cent in calcium carbonate by applying the mixture at 320 pounds per acre. Treatments were made with a *Root* rotary hand duster of the type commonly supplied malaria control units.

A plot was treated with DDT dust in comparison with straight calcium carbonate. Rains began falling a few hours after the dusts were applied and continued for two days. There was no opportunity to observe the effects of the treatment until three days after application. Therefore, another plot was treated with 5 per cent DDT dust to secure a 24-hour observation and to evaluate its performance under more normal weather conditions.

The results of the tests with dusts are shown in table 2.

The data show that the DDT dust caused a considerable reduction in mite activity but that the treatment was not completely effective. Because of the great variability in boot counts it was difficult to evaluate the degree of control, but it appeared that there were roughly 80 per cent fewer mites active during the period of 1 to 5 days after the dusting. Mite activity was indicated to be increasing when examinations were made after 8 and 12 days. No further records were taken because the writer left New Guinea after making those observations.

CONCLUSIONS.—The spray experiments indicated that DDT, diphenylamine and diphenylene oxide at 5 per cent concentrations did not add to the effectiveness of diesel oil. Tests with 5 per cent DDT applied as a dust showed that this insecticide was toxic to *Schongastia* larvae but that a dust application afforded neither complete nor long-lasting control.

The results with diesel oil alone showed that a spray application of 40 gallons per acre was sufficient to stop mite activity for at least one day after treatment but that applications made at twice and four times this rate did not appreciably prolong the protective period.

The tests indicated that diesel oil applied at two-day intervals at a rate of 40 gallons per acre would assure a cessation of mite activity. Such a procedure might be practical as an adjunct to clearing operations for troops encamping in typhus areas.

SUMMARY.—Small scale field tests were made in a rain forest area in Dutch New Guinea against larvae of *Schongastia pusilla* and *S. blestowei*. Sprays and dusts were applied to the surface of the forest litter which harbored the mites.

Spray tests were made using 5 per cent solutions of DDT, diphenylamine and diphenylene oxide in diesel oil. Diesel oil alone at 40 gallons per acre caused a temporary cessation of mite activity but some chiggers could be found crawling on the third day after treatment. There were no measurable differences in the effectiveness of diesel oil applications at rates of 40, 80 and 160 gallons per acre. None of

the three insecticides added appreciably to the effectiveness of diesel oil.

A dust consisting of 5 per cent DDT in calcium carbonate applied at 320 pounds per acre caused about 80 per cent reduction in mite activity during the first five days after treatment. Observations made 8 and 12 days after dusting indicated that mite activity was increasing.

It was concluded that DDT, diphenylamine and diphenylene oxide were of little value for this type of chigger control, but that frequent spraying of diesel oil might be practical as an adjunct to clearing for the control of chiggers infesting camp sites in scrub typhus areas.

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DDT for Insect Control at Army Installations in the Fourth Service Command[1]

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During the rapid mobilization of the Army in 194 and 1941 many problems of insect control, affecting the health and the morale of the new soldiers were encountered. Only the few entomologists who held commissions in the Sanitary Corps were readily available for assignments to the problems; there were not enough of these for one to be assigned to each major post.

Since most of the posts under construction in this Service Command were in or adjacent to potentially dangerous malarious areas the problem of malaria control was paramount. It was therefore necessary for the entomologists and sanitary engineers to devote the majority of their time to mosquito surveys and control which at this time was under the direct control of the Medical Department using Quartermaster and Medical Department funds. Most of the household insect problems such as fly, roach and bedbug control were accomplished by the individual units in accordance with the then existing Army regulations, and only meager assistance was available from entomologists even if one were on duty.

The in ecticides in general use during this time for household insects were a general purpose spray containing pyrethrum, and a sodium fluoride-pyrethrum roach powder. Diesel oil and used motor oil were used as fly and mosquito larvicides.

In July 1942 the Corps of Engineers was assigned the duty of accomplishing control of insects and rodents infesting real property at posts, camps and stations, upon the recommendation and under the technical supervision of the Medical Department using Corps of Engineer funds. Much the same type of control work was used during 1942 as that done previously. Roach control varied at different posts, the degree of control obtained depending on the Commanding Officers and upon training and instructions given mess officers and mess personnel by the Sanitary Corps officers. Bedbug infestation did not become general until early 1942. The recommended methods of control included airing and sunning the bedding, spraying with the Quartermaster issue contact spray which

[1] Including summaries of tests conducted at Camp Blanding, Florida, by Lieutenant Y. J. McGaha and Lieutenant N. N. Papandrea, SnC, at Fort Bragg, North Carolina, by Captain George D. Jones, SnC, and at Camp Gordon, Georgia, by Captain H. N. Kingsbury and Lieutenant R. W. Nelson, SnC.

[2] Major, Sanitary Corps.

[3] Senior Entomologist, Corps of Engineers.

[4] In addition to the persons listed the authors wish to acknowledge the assistance of the Insect and Rodent Control Section, Office of the Chief of Engineers, the staff of the Orlando Laboratory, Bureau of Entomology and Plant Quarantine, whose research and guidance formed the basis for these tests, and of Post Engineers and entomologists at the various Posts, Camps and stations who carried out the details of the work.

contained some pyrethrum, and the spraying of beds, mattresses and walls with kerosene or Quartermaster issue insecticide spray. Heat treatment for control of bedbugs was tried in a few cases with varying results. The barracks buildings were in general loosely constructed and were not well adapted to control by heat. These treatments were partially successful only under optimum conditions of high outside temperature and very little wind. It is believed that at best they served only to reduce the infestation temporarily. The use of hydrocyanic acid gas as a fumigant for bedbug control was not authorized in the Fourth Service Command until late in 1943.

During this period prior to the use of fumigation the post surgeon and the post engineer and personnel in charge of service clubs and officers' clubs were called upon frequently by salesmen representing various commercial insecticide companies, who sometimes brought considerable pressure to bear to complete their sales. None of the insecticides offered was superior to those available through Quartermaster channels, but considerable sums were spent by uninformed officials for borax, kerosene-thanite or kerosene-lethane mixtures which were merely better perfumed than the otherwise similar Quartermaster issue materials or for a complex cresol mixture said to be effective against mosquito larvae, bedbugs, ants and termites.

Fumigation during this period was done by contract at a cost of from $1.50 to $3.00 per 1000 cubic feet, the former figure being somewhat nearer the average. Roach control under contract was charged for at a rate averaging $3.00 per building per month. Aside from the high cost of such treatments, the effects were found to be far from satisfactory, often due to hasty or improper application of roach powders and pastes. In the case of fumigations, there were two fatalities and several near escapes with the contract operators, which alarmed post personnel and created a situation where control of insects was deliberately ignored or resisted.

In August 1943, therefore, a policy was established of using entirely War Department personnel for the control of all insect and rodent infestations at installations in the Fourth Service Command. For this purpose, a series of training "schools" was inaugurated. These were conducted by the Army Medical Department and the Corps of Engineers and were held at various posts in the seven states comprising the Fourth Service Command: North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi and Tennessee. The schools were based upon a small amount of lecture material and an intensive period of practice under the direction of the entomologists covering several days and giving each person attending the school a chance personally to apply roach powder with plunger dusters, participate in fumigation of buildings with HCN discoids and to engage in other insect and rodent control measures. Twenty-six schools were held and 886 men were trained including officers, enlisted men and civilians. Further indoctrination and training was carried out at Posts to insure that all men employed for pest control crews were adequately trained for fumigation and other work. It became immediately apparent that good insect and rodent control was being achieved by means of these trained crews and costs were lowered very appreciably. From the $1.50 per 1000 cubic feet paid for contract operators, the cost of fumigation dropped to as low as 35 cents per 1000 cubic feet in many cases and averaged 46 cents for all types of buildings and all areas. Soldier labor was little used but where used was added to the costs at the prevailing civilian rate. A dosage of 6 ounces of HCN per 1000 cubic feet was found to be sufficient for 100 per cent kills at 8 to 12 hour exposures. Several thousand buildings were fumigated, mostly 63-man barracks containing about 40,000 cubic feet of air space each.

Malaria Control.—As has been stated mosquito control has been a major sanitary and entomological project in the Fourth Service Command. When mobilization started in 1940 existing military installations had to be enlarged and many new camps constructed to take care of the rapidly expanding Army. This Service Command included the majority of the heaviest malaria areas of the country. The fact that troops from all parts of the country were brought together in a single camp made it doubly important that malaria vectors be controlled if the malaria rate for troops stationed in this Command were to be kept at a minimum.

Early in 1941 malaria surveys were made on all activated posts in the Command and actual control work was started in April and May of that year, when twenty-seven posts received funds for the program. Five of these posts were in Louisiana which has since been transferred to the Eighth Service Command. During the calendar year 1942, thirty new posts doing mosquito control work were added to the twenty-seven already in operation. In 1943, 46 additional posts started mosquito control, bringing to 103 the total of military installations doing this work. In 1944, the maximum of 121 such control programs was reached.

Control measures undertaken included clearing, channeling or ditch cleaning, new ditching, filling, ditch lining, and larviciding. The amounts of this work accomplished to date and the approximate unit cost expressed in man hours are given in table 1.

Table 1.—Relative amounts of various types of mosquito control work done in the Fourth Service Command 1941–45.

TYPE OF WORK	AMOUNT ACCOMPLISHED	AVERAGE MAN-HOURS PER UNIT
Clearing (Acres)	39,476	85
Channeling (Linear feet)	19,136,159	0.111
New Ditching (Linear feet)	4,927,808	0.75
Fill (Cubic yards)	1,881,562	1
Ditch lining (Linear feet)	990,863	
Larviciding (Acres)	219,355	7

In 1942 an average of 23 gallons of oil per acre was used in larviciding. In 1944 the amount of oil per acre dropped to 15 gallons. In 1945, when DDT was used as a larvicide on a number of posts, the average dropped to 8.67 gallons per acre including the oil used as a solvent for DDT. A total of 3,158,961 gallons was applied in the 5 years, averaging 14.4 gallons per acre.

In the spring of 1945 DDT was used in large scale experiments as a mosquito larvicide. It was found that DDT used as a larvicide materially reduced the amount of oil and labor necessary to effect control. DDT applied at the rate of 0.2 to 0.3 pound per acre, in 3 to 5 gallons of diesel oil, gave residual control for approximately 2 weeks. Table 2 is a comparison of DDT and diesel oil #2 at selected posts in the Service Command.

Table 2.—Comparison of amounts of plain diesel oil and DDT in diesel oil used and the man-hours required to apply them at representative posts, Fourth Service Command, 1941–45.

DATE	OIL USED	ACRES TREATED	MAN HOURS	GALS/ ACRE	MAN HOURS/ ACRE
	(Gals)				
July 1944	49,237	2,644	21,383	18.6	8
July 1945	15,449	4,134	12,146	3.7	2.9

Since DDT became available, effective adult mosquito control has also been achieved. An experiment carried on at Camp Murphy, Florida, in the summer of 1944 demonstrated conclusively that a residual treatment of 5 per cent DDT in kerosene applied to the interior barrack walls, in dark corners, under beds, etc., would provide protection. Camp Murphy was located adjacent to an area where there was extensive *Aëdes taeniorhynchus* breeding and where larval control was impractical. During July, August and September the post was subjected to an extremely heavy infestation of *A. taeniorhynchus*. Even though bed nets were used in screened barracks considerable annoyance was experienced by the troops. After 5 per cent DDT in kerosene was applied as a residual spray at the rate of 1 quart to 250 square feet of wall surface, no bed nets were needed in the treated barracks. During the summer of 1945, 5-per cent DDT spray was used in routine fashion in controlling adult mosquitoes in posts located adjacent to breeding areas where larval control was impractical. In all cases good results were obtained.

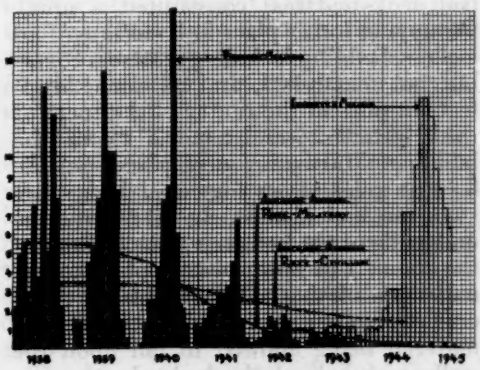

FIG. 1.—Malaria rate per 1000 men in Fourth Service Command, January 1938 to September 1945, inclusive.

As a result of an intensive mosquito control program the malaria rate for military personnel located in this Service Command has steadily decreased since the program started in 1941. This is shown in figure 1.

CONTROL WITH DDT.—With the advent of DDT in quantity in early 1944, a series of large-scale tests was inaugurated at posts in the Command for the purpose of determining the efficacy of the laboratory methods, already perfected by the Orlando, Florida, laboratory of the Bureau of Entomology and Plant Quarantine, when used under average field conditions at Army posts. These tests were designed to compare application methods as well as to compare DDT with other materials previously used for the purpose. They consisted of treatments applied at first to limited numbers of barracks and mess halls and then generally for control on entire posts. Tests included control of adult and larval mosquitoes, bedbugs, roaches, flies, ants, fleas, termites, pubic lice and ticks.

DDT AGAINST BEDBUGS IN BARRACKS.—Army barracks and "hutments" which were heavily infested with bedbugs were selected for the test to compare DDT 5 per cent in kerosene, DDT emulsion 5 per cent strength, fumigation by HCN discoids and the Quartermaster issue thiocyanate insecticide containing 5 per cent thiocyanate and 95 per cent kerosene.

The 5 per cent DDT in kerosene, the Quartermaster thiocyanate spray and the 5 per cent DDT emulsion were applied at the rate of 1 quart of material per 10 units. (For the purpose of the test, 1 bed or 1 mattress constituted a unit). Occupying forces placed all clothing, foot lockers, bedding including mattress covers but not mattresses, and all personal effects in piles in the center of the room or these articles were removed from the building. Mattresses were placed on the floor in piles seven high and beds were stood on end against the wall with the underside of the bed facing the interior of the room. The spray was applied to the underside of the bed, particularly to all crevices, joints and springs, the surplus material being allowed to fall upon the wall areas behind the beds. In treating the mattresses, particular emphasis was placed on the application of the material to all crevices and seams; gas mask carriers and other web equipment were left on the ends of the beds to receive a portion of the spray excess. At the end of the treatment of beds and mattresses any remainder of the spray was applied to the wall and especial attention was given to joints and crevices in the studding and to the lower 3 feet of the siding until the calculated amount had been applied.

Application was made by means of power sprayers, hand sprayers or paint brushes, and was continued until all surfaces were wet. It was soon found that power sprayers presented two grave difficulties. They tended to produce a fog rather than a wet spray and they required considerable attention, adjustment, untangling of lines, etc. The use of three gallon, hand operated, cylindrical pressure-tank sprayers was found to be the most economical of time and effort and to provide the best type of fine, wet, fogless spray. About four short pumpings sufficed to expel one tank full of material which was sufficient for one two-story, 63-man barrack. Bedbugs were very occasionally found crawling in buildings some days after treatment with DDT but this was considered normal since the bedbugs secreted in the deeper crevices in the walls would need to emerge before they could come into contact with the DDT and they would then live for varying periods thereafter. In only one case was a bite recorded after treatment. With this exception, control was uniformly 100 per cent. Treatment with thiocyanate spray effected a reduction of from 50 per cent to 75 per cent and in most cases lasted a short time only.

Careful counts were made of the numbers of bedbugs on each bed in each of the several hundred buildings treated at four of the largest posts in the Command. Following treatment, careful counts were again made and these were repeated at weekly intervals for 6 weeks. More than a year later retreatment with DDT has not been found to be necessary and this has remained true also of the treatments applied generally on all posts in the Command following completion of the tests. With fumigation, or treatment with thiocyanate spray, retreatment had been found to be necessary at the end of about seven months for 18 per cent of the buildings. The cost of spraying with DDT

averaged about 7.5 cents per 1000 cubic feet or about $3.00 per 63-man barrack. Costs, man hours and amounts of DDT used for selected types of buildings are shown in table 3.

Table 3.—Comparison of costs of applying DDT in various types of buildings for bedbug control, Fourth Service Command, 1944–45.

TYPE BLDG. AND TREATMENT	NO. BLDGS.	GALS DDT PER BLDG. (AVER.)	MAN-HOURS PER BLDG. (AVER.)	COST PER BLDG. (AVER.)[1]
Barrack 63-man complete	472	4.15	4.10	$2.89
Barrack 63-man spot	14	2.90	3.30	$2.81
OQ-40[2] complete	2	16.00	9.00	$7.65
OQ-40[3] spot	8	3.90	3.90	$3.31
Hutments 5-man	83	0.50	0.50	$0.27
Hutments 16-man	135	2.00	1.10	$0.54

[1] Cost of labor only. Cost of DDT, 5% in kerosene, or 0.90 per gallon. ($3.73 per average 63-man barrack should be added.)
[2] OQ-40: Officers Quarters, 40-man, individual or 2-man rooms presenting far more wall space than barracks having usually, only 3 to 5 2-man rooms and 2 large general rooms.
[3] 39,000 cu. ft. or 7.5¢ per 1000 cu. ft.

FLY CONTROL WITH DDT.—Prior to the advent of DDT, fly control was mainly dependent upon the spraying of breeding areas (such as the ground below garbage racks, manure piles, etc.) with diesel oil No. 2 and upon the use of fly traps, sticky fly-paper strips, and the like. Oiling gave good control where sufficient amounts of oil were used and where sufficient time and care were expended in applying it. Fly traps were of problematical value even when they were properly baited, which was seldom.

The tests for control of adult flies with DDT included treatments at six major posts of the following types of place and with the following materials:

1. Inclosed pit latrines: Interior walls, screens, and exterior of pit box with 5 per cent emulsion, with 5 per cent kerosene solution, and with 10 per cent dust.
2. Inclosed pit latrines: Interior of box and walls of pit only, with same materials and with diesel oil No. 2.
3. Open pit latrines: Interior of box and pit walls only, with same materials and with diesel oil No. 2.
4. Garbage racks, using same materials as in 2 and 3.
5. Interior of mess halls: Screens, overhead pipes, rafters and other places shown by fly-specks to be favored resting places, treated with 5 per cent emulsion, 5 per cent DDT solution in kerosene, Quartermaster issue (5 per cent thiocyanate) spray, 2.5 per cent thiocyanate spray with 1 per cent DDT.
6. Dairy barns: Treated as in 5 but with 5 per cent DDT solution only.

Following all DDT residual treatments, the fly population was reduced by from 70 to 100 per cent, with one exception to be discussed later, and remained at this low point for 4 to 6 weeks. In some closed latrines, the treatments were effective for 3 months. The type of material did not affect results except that space-type sprays, containing thiocyanates and intended only for quick knock-down, did not prove satisfactory. However, where these contained 1 per cent DDT and were directed heavily upon the walls, the results were good. This does not, of course, invalidate the use of the thiocyanate in a 5 per cent spray to increase knock-down and give immediately apparent results. In the army use, the need for this was usually not a factor. Spraying of the pit and interior of box in latrines was slightly more effective than spraying screen and interior of buildings. DDT appeared not to be an effective fly larvicide and was erratic in its effect upon the "soldier" fly, *Hermetia illucens*, which, however, is not a disease vector.

Although, in general, control of flies was good even in tents and in mess halls where screen doors were faulty or were habitually left open, in one instance the influx of flies was so great that no reduction could be noted following a thorough treatment with DDT. These flies were coming from a dairy barn some 500 feet away.

This barn was unscreened, and in spite of the fact that all windows and doors were closed once each day and a commercial solution sprayed by power until

the room was filled with fog, the flies were so thick that they literally jostled each other on the walls. Following treatment, the number of flies dropped to 2 to 3 in the entire building and this condition lasted some 4 weeks, after which the population gradually increased to normal. Following a sudden dropping of the temperature at the end of 6 weeks, the material again killed all flies in the building overnight. Other barns were then treated at several posts with resultant reductions of fly populations which, 2 weeks after the treatment, were still as low as from 16 per cent to only 5 per cent of the original population. These barns ranged from a screened dairy barn to unscreened barns and open-sided bull and heifer pens. Spraying of manure compost piles was also found to be effective in preventing the emergence of adults or continuation of breeding. Table 4 gives costs of treatments, amounts of DDT and man hours consumed in the treatments with DDT for fly control which have become standard practice at all posts in the Fourth Service Command. These practices have so reduced fly populations that at one post where the cantonment area is more than the flight range from the borders of the post, only 2 adult flies were seen during a 2-day inspection of the post at the height of the fly season.

Table 4.—Comparison of costs of applying DDT in various types of buildings for adult fly control, Fourth Service Command, 1944–45.

Type Bldg. and Treatment	No. Bldgs.	Gals. DDT per Bldg. (aver.)	Man-Hours per Bldg. (aver.)	Cost per Bldg. (aver.)[1]
Complete Mess Hall Treatment	1014	2.81	2.74	$1.78
Partial Mess Hall (screens & racks only)	709	0.79	1.46	$0.85
Latrines	80	0.85	1.30	$0.84
Bakery	1	14.00	12.00	$10.20
Garbage Racks	1518	1.07	0.77	$0.40
Complete Fly & Roach Treatment	408	8.00	6.00	$3.50
Dairies	7	3.4	1.6	$0.90

[1] Cost of labor only. Cost of DDT, 5% in kerosene, or .90 per gallon ($2.53 per mess hall, complete treatment) should be added.

ROACH CONTROL.—Until the tests with DDT, control of both the American roach, *Periplaneta americanum*, and the German roach, *Blatella germanica*, was satisfactorily obtained with sodium fluoride powder as issued by the quartermaster either with or without added pyrethrum. In order to obtain this control, the powder was blown with a small plunger duster into all crevices in walls and tables, the thoroughness and not the heaviness of the application being the prerequisite of success. In many cases, where wallboard, partitions or extra shelving prevented direct access, holes were bored into the concealed cavities and dust blown through the holes. Scattering the powder with a spoon or spatula, sprinkling from the can or other similar methods was not found to be effective but where care was exercised in applications made with a duster, the control was excellent.

The same method of applying the dust was used with DDT in making the large-scale tests. In addition, other buildings were sprayed with the 5 per cent kerosene solution and the emulsion up to 20 per cent, applying enough to run slightly so that all crevices were well filled. Results varied but it was evident that to an even more marked degree than with sodium fluoride, complete coverage of all crevices was essential. A combination of treatments using both 5 per cent solution in kerosene and 10 per cent dust gave excellent results wherever tried. The use of the emulsion did not seem to be more effective even with a higher percentage of DDT. From 0.5 to 3 pounds of DDT-pyrophyllite 10 per cent dust applied in 2 to 3 applications was found to be necessary for satisfactory control and about 2 to 4 gallons of the 5 per cent solution to a 250 man mess hall. These buildings are about 20 by 100 feet in area. Retreatment was required after 6 weeks. Subsequent treatments on posts throughout the Command have shown that a somewhat heavier initial application followed after one week by another thorough treatment will give such good control that only a relatively small "spot-treatment" at monthly or even somewhat greater intervals will be required to keep the mess hall

virtually free of roaches. In practice, the treatment for flies and roaches is now combined, using about 3 to 4 gallons of spray and 3 pounds of dust per building which, with subsequent spot treatments by the occupying forces, using the 10 per cent dust and a 1 per cent spray, will suffice for the better part of a summer. Mixtures of sodium fluoride and 10 per cent DDT powder gave as good but not better control than DDT alone, when properly applied.

Fumigation was never recommended by the Headquarters, Fourth Service Command, for the control of roaches, due to the temporary nature of its effectiveness, but it was occasionally accomplished upon the recommendation of the Post Surgeon where extremely heavy infestations had been allowed to build up and it was desirable not to wait the 3 to 4 days necessary to secure control with sodium fluoride or where the Post Surgeon or others in authority were fearful of the use of this latter poison. The cost of fumigating a company mess, containing about 20,000 cubic feet averaged $9.20.

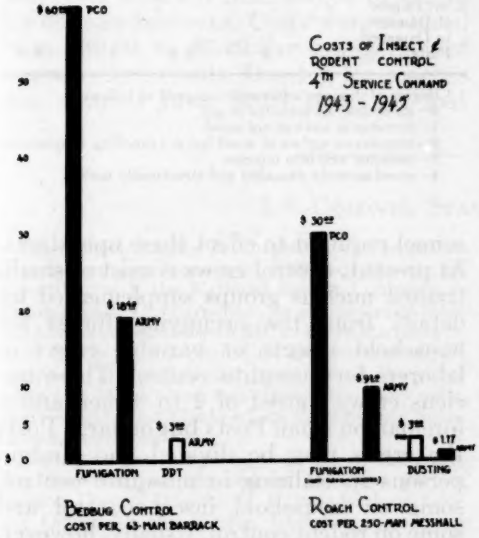

FIG. 2.—Comparative costs of insect control by contract and by Army personnel using fumigation, sodium fluoride and DDT, Fourth Service Command, 1943–45.

Between the application of DDT and sodium fluoride no difference in cost exists, other than the hypothetical cost of the material, which is quartermaster issue. This is a difference of between 23 cents per pound for sodium fluoride in 5-pound lots and 16 cents per pound for DDT 10 per cent dust in pyrophyllite, or a presumptive $0.69 per building for sodium fluoride compared with a presumptive $0.48 per building for DDT, for the initial application. These costs are shown in figure 2.

Since the completion of the tests several thousand buildings have been treated for roaches or for roaches and flies together. Of those buildings treated for roaches and by one type of treatment alone, a sample of 1869 buildings showed that 1113 were dusted and 756 sprayed. An average of 2.7 man-hours was consumed per building; 1½ pounds of dust were used per building and 2.1 gallons of spray were applied per building. The cost per building ranged from $0.35 to $6.00, depending on the size or type of the building, some of them being 1000-man messes or elaborate officers' or service club buildings. The average cost per treatment during the entire season was $1.17 a building.

TERMITES.—In the routine termite control especially at the older and permanent posts, DDT 5 per cent in diesel oil has been compared with various other materials, including chlorinated toluene 10 per cent in waste motor oil, pentachlorphenol 5 per cent in waste motor oil, creosote-diesel oil mixture 1:2 and sodium arsenite 10 per cent solution in water. These control tests, using several hundred nearly identical buildings, have not, of course, been continued long enough to be conclusive. However, certain results might be mentioned. The use of sodium arsenite solution at the rate of 1 gallon per 5 cubic feet of trenching along foundations was found to be incompletely effective. At 2 gallons per 5 cubic feet, control was obtained but some damage to shrubbery outside the foundation wall occurred. The tests are being continued.

Tests were also conducted near West Palm Beach, Florida, at a Post having tar-paper buildings resting upon untreated wooden supports placed without footings directly in the soil. Within 14 months after construction, extensive replacements had been required. Four buildings were then taken and the 33 uprights beneath each were divided into 6 randomized blocks. Treatments were applied at random within the blocks as follows:

1. Ten pounds DDT were dissolved in 25 gallons diesel oil No. 2. Uprights and 2 by 6's for footings were dipped in solution and allowed to remain 24 hours. Solution was sprayed into the hole and onto the spoil as it was added gradually around the upright. One quart of solution was used per hole of 4 cubic feet.
2. Twenty pounds *duPont NC* compound was dissolved in 10 gallons used crankcase oil and applied to soil as hole was refilled at rate of 1 gallon per 10 cubic feet as recommended by the manufacturer.
3. Five per cent aqueous solution of arsenite was similarly applied at a rate of 1 gallon per 5 cubic feet.
4. Creosote and diesel oil mixture 1:3 was applied as above.
5. Untreated check.

Unfortunately the test may have to be discontinued at this time after 17 months of operation. However, on an inspection made on 13 and 14 November 1945 the figures given in table 5 were obtained.

This examination disclosed that none of the Posts treated with the DDT solution had been approached by termites, there were no termites in the soil around the posts and in addition the wood was fresh and new in appearance and showed no signs of dry rot or decay. Posts treated with the duPont compound and with sodium arsenite had deteriorated about equally from both termites and decay, 16.6 per cent and 20.8 per cent of the posts being damaged respectively, the damage being insufficient to cause structural failure of the timber. Sodium arsenite had apparently not leached out in the heavy rains to as great an extent as the creosote, surprisingly enough. Creosote-treated soil had failed to protect 62.9 per cent of the timbers so treated and the termite damage was usually severe. Untreated uprights were virtually completely destroyed below the ground line by rot and termites and above the ground line were but shells because of the termite feeding. All damage was accompanied by still active colonies.

Table 5.—Damage by termites to four by four uprights arranged in randomized blocks and treated at random with various chemicals. West Palm Beach, Florida, 1944–45.

Bldg. and Block	Treatment 1 (DDT)	2 (duPont)	3 (NaAsO)	4 (Creosote)	5 (Check)
T-379					
A	0[1]	1	0	2	4
B	0	0	0	0	4
C	0	0	1	3	4
D	0	0	0	0	4
E	0	0	0	0	0
F	0	0	0	0	4
T-389					
A	0	0	0	2	4
B	0	0	0	0	4
C	0	2	3	4	4
D	0	0	0	3	3
E	0	0	0	0	4
F	0	0	0	1	4
T-491					
A	0	0	0	3	4
B	0	0	0	3	4
C	0	0	0	0	4
D	0	0	0	3	4
E	0	0	0	1	4
F	0	0	0	3	4
T-431					
A	0	3	3	4	4
B	0	0	3	0	3
C	0	0	0	4	4
D	0	1	0	4	4
E	0	0	3	0	4
F	0	3	0	4	4
Total	0	10	13	44	90
Average Degree Damage	0	.42	.54	1.82	3.75
Per Cent Post Damaged	0	16.6	20.8	62.9	95.8
Aver. Degree of Damage to Damaged Posts	0	2	2.6	3	3.9

[1] Degree of damage arbitrarily assigned as follows:
0—no attack; no termites in soil.
1—termites in soil but not wood.
2—termites on surface of wood but not tunelling into interior
3—termites well into interior.
4—wood severely damaged and structurally useless.

PRESENT PROCEDURES.—DDT treatments last longer than those previously used for general insect control and the use of the material in the various phases of insect control on the posts has therefore reduced both the time and the personnel required to effect these operations. At present, control crews consist of small, trained nucleus groups supplemented by details from the occupying forces for household insects or variable crews of laborers for mosquito control. These nucleus crews consist of 2 to 3 men and a foreman on small Posts but on large Posts the crews may be divided and contain persons specializing in mosquito control, some on household insect control and some on rodent control. Usually, however, the personnel even on larger crews operate in all phases of the work, shifting emphasis as the season or the findings of the Sanitation Officer and the Pest Control supervisor may require.

SUMMARY.—Mosquito control occupied the dominant position of importance in the early days of the mobilization, especially since the majority of the posts in

the Fourth Service Command were located in or near swamps in highly malarious areas. Since early in 1944 cases of imported malaria occurring in Troops returned from overseas duty has increased to a point which approximates that which occurred in this country before control was instituted. Despite these facts, the primary malaria rate has been held low and has steadily decreased until in 1945 it was virtually non-existent. In 1942 bedbug control became a major problem. At first, control was attempted with heat and pyrethrum or thiocyanate sprays but by late summer of 1943 fumigation with HCN was authorized. Schools were thereupon held for the training of Medical Department and Corps of Engineer personnel including pest control supervisors, foremen and crews; later these schools and indoctrination courses also gave instruction and practice in the use of DDT. Twenty-six such schools were held, training 886 officers, enlisted men and civilians. Cost of operations by Army personnel in this Command were very materially less than those for contracting the same work to be done by outside operators. Fumigation costs were cut from $60.00 to $18.40 for 63-man barracks. Costs were reduced from $30.00 to $9.20 for fumigation of company mess halls. Dusting for roaches was reduced from $3.00 to $1.17, and even less, and complete control has been effected.

With the advent of DDT in early 1944, large-scale tests were conducted on the application of methods developed at Orlando, Florida, to practical control work on Army posts. These tests covered control of mosquitoes, flies, bedbugs, roaches, ants, fleas, termites, lice and ticks. Application of DDT sprays by means of hand-operated, cylindrical, pressure-tank type sprayers was found to be the most economical of time and effort and to give the best type of spray. Dusts were best applied with hand-operated plunger dusters. Control of flies and bedbugs was spectacular and good control of all insects was secured.

Termite control has been accomplished with DDT, 5 per cent in kerosene, in tests comparing it with chlorinated toluenes, pentachlorphenol, creosote-diesel oil mixtures and 10 per cent sodium arsenite solution in water. With the exception of the two latter, no failures have occurred.

Insect and rodent control is now done by small, well-trained, nucleus crews which usually operate in all phases of the work, with the assistance of military personnel or general laborers as needed. Corps of Engineers funds are used to perform all work which is not considered a housekeeping function.—12-17-45.

LT. COLONEL STANLEY J. CARPENTER

Lt. Colonel Stanley J. Carpenter was separated from the army on January 28, 1946 and has accepted a position with the National Biscuit Company as Entomologist. Dr. Carpenter, as we may once more call him, is associated with Mr. J. Lloyd Barron who is in charge of the Sanitation Department of the company. Included in his duties are all the insect control problems which must arise in the many mills, bakeries and other plants which the company maintains in many locations.

During his nearly 5 years of service in the army, Dr. Carpenter was engaged for the most part in Malaria Control Operations. He was Malaria Control Officer for the Persian Gulf Command and organized this work around the U. S. Construction bases in Iraq and Iran; later he was head of the Entomology Department of the Fourth Service Command and later, his last assignment was a similar position with the Ninth Service Command at Monterey, California. His rise from his entering rank of Captain to that of Lieutenant Colonel indicates the official evaluation of his work.

Dr. Carpenter's present position is one more indication of the expanding field for employment open to entomologists and shows that the need for, and the value of, entomological service, is being recognized by commercial concerns and can not fail to be a cause for professional satisfaction among entomologists.

Dr. Walter Ebeling has transferred his work from the Citrus Experiment Station of the University of California, at Riverside, to the University of California at Los Angeles and may now be addressed as follows: University of California, Division of Entomology, 405 Hilgard, Los Angeles 24, California.

Mr. James W. Hansen has accepted a National Institute of Health fellowship and has returned to the University of California, at Berkeley, to complete his graduate work in Entomology. His present address is 1640 Euclid Ave., Berkeley 4, California.

Effect of Short Contact with DDT Residues on *Anopheles gambiae*[1]

LEO KARTMAN,[2] and MARIO M. DA SILVEIRA[3]

The use of DDT (2,2-bis(p-chlorophenyl)-1,1,1-trichloroethane) residues against adult mosquitoes both in the laboratory and on a practical scale has already been decisively demonstrated by work at the Orlando, Florida Research Laboratory of the Bureau of Entomology and Plant Quarantine. In this connection, it may be of some academic, if not practical, importance to record results of tests on *Anopheles gambiae* Giles[4] in which this species was allowed only very short contact with DDT residues.

Gahan *et al.* (1945) cite experiments with *Anopheles quadrimaculatus* Say in which exposures to DDT as short as 15 minutes were allowed. However, their method of exposing the mosquitoes in wooden boxes and canvas cages treated with DDT is quite different from the method employed by the present writers and it may be of some interest to give results of tests in which the effect of so short a contact with DDT as 5 seconds was evaluated.

These experiments on *Anopheles gambiae* were accomplished in the laboratory at an Army air base near Dakar, French West Africa during the months of July, August, and September of 1944. The efficiency of DDT residues as a control of *A. gambiae* and *A. funestus* in native villages near Dakar had already been demonstrated by the work of an Army Malaria Survey Detachment. However, it was desirable to learn something about the actual length of contact with DDT in relation to its toxic and lethal effects. These contact tests attempted to give a preliminary answer to the question.

MATERIALS AND METHODS.—Observations on the reaction of *A. gambiae* to DDT residues deposited on the walls of test boxes indicated that the mosquitoes were considerably activated. This fact prevented observations on actual length of contact with DDT and the box or cage method was abandoned.

A glass tube 8 inches long and 10 millimeters in diameter was fitted with a rubber tube at one end to make a mosquito aspirator. A coating of DDT was deposited on the inside surface of the aspirator tube at a dosage equal to 125 mg. of DDT per square foot. This compared with the average dosage of DDT used to control *Anopheles gambiae* under field conditions in native villages. A second aspirator tube exactly like the first, but untreated, was used to test control mosquitoes.

Female *Anopheles gambiae* were obtained from a stock colony fed on humans. There was some small variation in the ages of the test mosquitoes but the use of a large number reduced the significance of this factor. Although most of the mosquitoes used were laboratory bred, it should be noted that females collected in native huts were used on four occasions. It was decided to include data on these wild mosquitoes since the data showed their reaction to DDT residues was absolutely identical with that of laboratory bred mosquitoes.

Each mosquito was sucked into the aspirator separately and allowed to remain in contact with the DDT for a specified length of time. Continuous contact with DDT was insured by the small diameter of the tube. The mosquito was then gently blown into a small 18-mesh screen cage approximately 2 inches square. A separate cage was used for each mosquito being tested. Observations were then recorded on toxic and lethal effects of DDT. This same procedure was repeated on control mosquitoes with an untreated aspirator.

Anopheles gambiae females sucked up into these DDT-treated aspirators were never seen to be activated as in cages treated with DDT. In almost all cases the mosquitoes either remained quietly in one place or walked slowly back and forth. The DDT residue was contacted mainly with the legs and wings.

Observations were taken on 60-second,

[1] The writers wish to thank Captain Henry A. Dunn, Sanitary Corps, A.U.S., for suggesting the project and for his interest and cooperation. Thanks are also due T/4 Eldon H. Newcomb, Medical Department, A.U.S., who was in charge of the anopheline stock colony.

[2] Second Lieutenant, Sanitary Corps, A.U.S.

[3] Medical Department, Government of Brasil.

[4] *Anopheles gambiae* Giles (=*costalis* Giles).

30-second, and 5-second contacts with DDT residues. The 60-second contact was tested 17 times over a period of 23 days, using an average of 29.4 mosquitoes per test and an average of 5.5 mosquitoes for check tests. As indicated above, 4 of these 17 tests were done with female *Anopheles gambiae* taken in native huts. All other tests in all groups were done with laboratory bred females. The 30-second contact was tested 11 times over a period of 18 days, using an average of 46.6 mosquitoes per test and 9.4 per check. The 5-second contact was tested 10 times over a period of 12 days, using an average of 50 mosquitoes per test and 9.5 per check.

Since the same aspirator and the original DDT residue was used throughout these tests, this tube was checked for effectiveness at the end of the experiment by testing it against a fresh tube.

The criterion of DDT-toxicity was arbitrarily set at the first moment in which tremors of the legs or body were observed. The criterion of death was set at that moment when prodding with a sharp instrument elicited no observable response in any part of the body. For all practical purposes, death actually occurred before this time, but the above criterion was used since it gave a more uniform standard for observation.

No attempt was made to control temperature or humidity because facilities were lacking. There is, however, only a slight daily fluctuation of temperature during this time of the year at Dakar and it is believed that effects of temperature were not significant under the conditions of the experiment. Field work with DDT residues against *Anopheles gambiae* indicated that the insecticide was effective over a much wider range of temperatures than obtained in the laboratory. Recent experiments (Lindquist *et al.* 1945) have shown that DDT was active against houseflies over a wide range of temperatures.

All tests were begun in the morning with

Table 1.—Toxic and lethal effects of DDT residues to *Anopheles gambiae* females exposed for short periods in an aspirator tube treated at the rate of 125 mg. DDT per square foot.

Time (Minutes)	Mosquitoes Showing DDT-Toxicity After—					
	60-Second Contact		30-Second Contact		5-Second Contact	
	No.	Per cent	No.	Per cent	No.	Per cent
0–9	55	11.0	182	35.5	30	6.0
10–19	184	36.8	196	38.3	124	24.8
20–29	132	26.4	70	13.7	114	22.8
30–39	57	11.5	32	6.2	88	17.6
40–49	22	4.4	19	3.6	51	10.2
50–59	15	3.0	7	1.3	34	6.8
60–69	9	1.8	2	0.4	24	4.8
70–79	12	2.3	2	0.4	3	0.6
80–90	14	2.8	3	0.6	32	6.4
	Mosquitoes Dead					
0–59	40	8.0	26	5.1	8	1.8
60–119	118	23.6	141	27.4	30	6.0
120–179	97	19.4	92	17.9	42	8.6
180–239	92	18.4	82	15.9	55	11.0
240–299	32	6.4	53	10.3	69	13.2
300–359	29	5.8	28	5.5	44	9.0
360–419	33	6.6	27	5.4	49	10.0
420–479	45	9.0	26	5.4	37	7.6
480–539	14	2.8	5	0.9	10	2.0
540–599	0	0	16	3.1	28	5.2
10–24 hours	0	0	17	3.1	114	22.8
Alive after 24 hours	0	0	0	0	14	2.8
Total number mosquitoes used	500		513		500	
Number of tests	17		11		10	

observations lasting throughout the day for about 10 hours and the final observations were taken on the following morning, 24 hours later. The light was kept subdued throughout all tests.

DATA AND DISCUSSION.—Table 1 indicates the approximate time in which

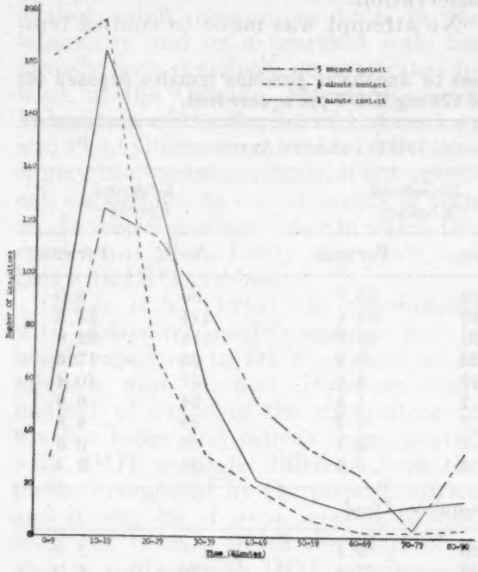

FIG. 1.—DDT-toxicity trends in female *Anopheles gambiae* after short contacts with residues of 125 mg. of DDT per square foot.

Anopheles gambiae females first showed typical toxic tremors and subsequently died after short periods of contact with DDT residues. Figure 1 gives the toxicity trend in curves for each length of contact with DDT.

Tests with starved mosquitoes showed that the first onset of tremors was not enough to inhibit most individuals from taking a blood meal. However, the intensity of syndromes induced by DDT-toxicity increased quite rapidly and most *Anopheles gambiae* females were not in condition to feed at between 1 and 2 hours after the onset of tremors. The greatest percentage of the mosquitoes showed DDT-toxicity between 10 and 30 minutes after short periods of contact with DDT residues.

The mortality picture is shown in tables 1 and 2, and in figure 2. The 60- and 30-second test groups show a similarity of mortality trends. The majority of these mosquitoes died well within 10 hours after contact with DDT. In the 5-second contact group there is a trend toward a higher mortality rate at between 10 and 24 hours after contact, although, even in this group, most of the mosquitoes had

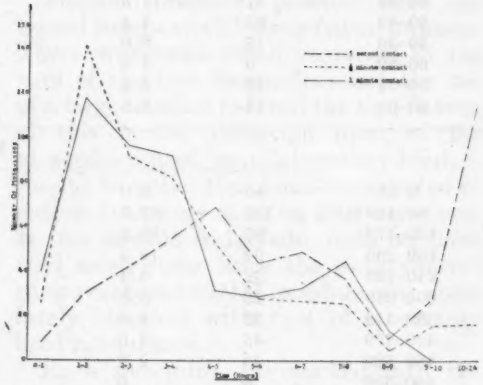

FIG. 2.—Mortality trends of female *Anopheles gambiae* after short contacts with residues of 125 mg. of DDT per square foot.

died by 10 hours. It should also be noted that more than 2 per cent of the latter group were still alive 24 hours after contact.

Table 3 gives data which indicate that DDT residues in the aspirator tube had not lost their original qualities after 55 days of use in these experiments.

It should be noted that by controlling the length of contact with DDT residues it was possible to produce a mortality of 97 per cent in 24 hours after a 5-second contact. This is interesting in connection with the tests cited by Gahan *et al.* (1945). These workers, using DDT-treated boxes, showed that *Anopheles quadrimaculatus* adults failed to give 100 per cent mortality in 24 hours after 15-minute, 30-minute,

Table 2.—Comparison of mortality of *Anopheles gambiae* females exposed for short periods in aspirator tubes treated with DDT and untreated.

TIME	PER CENT MORTALITY AFTER CONTACT OF—		
	60 seconds	30 seconds	5 seconds
8 hours	97	93	67
24 hours	100	100	97
	Controls		
8 hours	2	11	6
24 hours	47	59	49

and 60-minute exposures to as much as 400 mg. of DDT per square foot. A 2-hour exposure to this dosage gave a maximum mortality of 96 per cent in 24 hours and it took a 4-hour exposure to give the desired 100 per cent mortality. No record of actual length of contact could be kept since the mosquitoes spent much of the time in flying about within the test boxes. The results reported here, with the aspirator tube method, may possibly shed some light on the actual contact time required for a lethal dose.

SUMMARY.—Experiments are cited which tested the actual length of contact of *Anopheles gambiae* females with DDT residues in relation to toxic effect and mortality.

Female *A. gambiae* allowed 60-, 30-second and 5-second contacts in an aspirator tube coated with residues equal to a dosage of 125 mg. of DDT per square foot showed typical DDT-toxicity in less than 10 minutes after contact. The majority of individual showed toxic symptoms at between 10 and 30 minutes after contact. All mosquitoes were affected at between 80 and 90 minutes after contact.

Anopheles gambiae females allowed 60- and 30-second contacts with DDT gave an average of over 95 per cent mortality 8 hours after contact. The 60-second group gave 100 per cent mortality 9 hours after contact and the 30-second group gave 100 per cent mortality at between 10 and 24 hours after contact. Those mosquitoes allowed 5-second contacts gave 97 per cent mortality at between 10 and 24 hours after contact.

Toxicity and mortality curves for the 60-second contact group were very similar to such curves for the 30-second contact group. There was a general correlation between toxicity trends and mortality trends in all test groups.

The data suggest that an extremely short contact with DDT residues is sufficient to cause the death of most *Anopheles gambiae* females; such contact will give an approximate 100 per cent mortality well before 24 hours after exposure to DDT.

The data indicate that an extremely short contact with DDT residues is sufficient to inhibit most *Anopheles gambiae* females from taking a blood meal at between 1 and 2 hours after contact.—1-12-46.

Table 3.—Comparison of aspirator tubes to test effectiveness of DDT residues against female *Anopheles gambiae;* tube 1 with 55 day old residue of 125 mg. DDT per square foot; tube 2 with 10 day old residue of the same dosage.

TIME (Minutes)	MOSQUITOES SHOWING DDT-TOXICITY			
	Tube 1		Tube 2	
	No.	Per Cent	No.	Per Cent
0–9	7	4.2	13	7.1
10–19	32	19.1	62	34.1
20–29	38	22.6	45	24.5
30–39	27	16.1	17	9.3
40–49	20	11.9	11	6.5
50–59	11	6.5	13	7.2
60–69	8	4.7	6	3.2
70–79	4	2.4	1	0.5
80–90	21	12.5	14	7.6
	Mosquitoes Dead			
0–59	2	1.2	3	1.7
60–119	10	5.9	9	4.9
120–179	21	12.5	10	5.5
180–239	22	13.2	18	9.9
240–299	19	11.3	20	10.9
300–359	14	8.4	19	10.5
360–419	20	11.9	14	7.7
420–479	21	12.5	10	5.5
480–539	3	1.7	5	2.8
540–599	1	0.6	1	0.5
10–24 hours	35	20.8	64	35.2
Alive after 24 hours	0	0	9	4.9
Total number mosquitoes used	168		182	
Number of tests	7		7	

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DDT to Control Insects Affecting Man[1,2]

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Within the past 3 years DDT has become one of the most effective agents known for the control of certain insects affecting man. Mosquitoes, human lice, flies, fleas, and bedbugs are among the harmful insects that can be controlled with DDT. The importance of this insecticide as a means of controlling diseases transmitted by these insects has been clearly demonstrated.

The data which were drawn upon for the preparation of this manuscript have been obtained largely in connection with studies conducted at the Orlando, Fla., laboratory of the Bureau of Entomology and Plant Quarantine, where investigations on the control of insects and arachnids of importance to the armed forces have been under way since 1942. The United States Public Health Service and the Tennessee Valley Authority, as well as other agencies, have also contributed valuable basic information on this subject, and the Army and Navy have applied DDT in large-scale experiments and practical control operations in many parts of the globe.

Much has been written on the subject covered in this paper, consequently no attempt will be made to refer to the work of all the many investigators who have taken part in the research on DDT. An attempt will be made, however, to summarize our knowledge of the use of DDT for the control of the more important insects affecting man, with particular emphasis on how the insecticide can be employed in practical control operations and the type of formulations that have been found useful.

TYPES OF DDT PREPARATIONS.—DDT is not only effective against a wide variety of insects, but it also has the advantage that it can be used in a number of formulations. It has been found useful for specific purposes as dusts, solutions, emulsions, and suspensions (Jones *et al.* 1945a).

As a dust it can be employed with various diluents, including talc and pyrophyllite, the concentrations generally ranging from 1 to 10 per cent.

Solutions of DDT in petroleum oils, including lube oil, fuel oil, kerosene, and some of the lighter fractions, have been widely used. Other types of solvents have also been employed, especially in concentrated sprays for use in aerosols and space sprays and in connection with the airplane application of sprays. Cyclohexanone, alkylated naphthalenes, and xylenes have been employed, either alone or as auxiliary solvents for other types of solutions. The concentration of DDT used has ranged from less than 1 to as high as 20 per cent.

DDT emulsions have wide uses in controlling insects affecting man, including lice, mosquitoes, flies, fleas and bedbugs. The first emulsion used consisted of DDT, xylene, and an aralkyl polyether alcohol (*Triton X-100*). For military purposes the emulsion concentrate contained 25 per cent of DDT, 10 per cent of *Triton X-100* and 65 per cent of xylene. Other agencies have used the same ingredients in different proportions (Simmons *et al.* 1945). Various solvents may be substituted for the xylene and a number of good emulsifiers other than *Triton X-100* have also been found.

Aqueous suspensions of DDT have not been widely employed, although they are very effective and desirable for certain purposes. Owing to the recent development of suitable commercial preparations containing from 50 to 90 per cent of DDT, they will no doubt be used more extensively.

DDT FOR THE CONTROL OF MOSQUITOES.—The use of DDT for mosquito control has already been summarized by Knipling (1945)[3] Simmons (1945), and Metcalf *et al.* (1945). It has been found highly effective against both anopheline and culicine mosquito larvae when used with ground equipment or dispersed by airplanes (Deonier *et al.* 1945a, b, c; Eide

[1] This work was conducted under a transfer of funds, recommended by the Committee on Medical Research, from the Office of Scientific Research and Development to the Bureau of Entomology and Plant Quarantine.

[2] Presented on the program of the Annual Meeting in Dallas, 1945.

[3] Knipling, E. F. Recent developments in the use of DDT and other mosquito insecticides and repellents. Paper presented at meeting of National Malaria Society, December 1945. See Journal of the National Malaria Society, June 1946.

et al. 1945). For adult mosquitoes it has three major uses—(1) as a space spray or aerosol for use inside buildings, either alone or in combination with pyrethrum or other rapid paralytic agents (Lindquist *et al.* 1945c, d); (2) as a residual or surface treatment for the destruction of adult mosquitoes that subsequently rest on the treated areas (Gahan *et al.* 1945a, b, c); and (3) for the destruction of adult mosquitoes outdoors by means of ground equipment or airplane (Lindquist *et al.* 1945a, Madden *et al.* 1945b, 1946).

Larvae.—DDT-petroleum oil solutions and emulsions have been employed extensively in connection with larvicide operations. The dosage of 0.1 pound of DDT per acre is recommended for routine applications. However, good control of *Anopheles* larvae may be obtained with lower rates of application. Against certain culicine genera, especially *Culex*, the indicated effective dosage is considerably higher.

Various types of sprayers, ranging from ordinary hand sprayers of the *Flit-gun* type to power units, may be employed for applying DDT larvicides. Since only a few quarts per acre of DDT sprays will give adequate control, the size of the orifice and rate of delivery of the sprayer should be carefully modified for proper application. Five quarts per acre of a 1 per cent solution is recommended for routine use. The concentration of DDT can be changed, however, according to the type of equipment available and the species of mosquitoes native to the breeding area. If sprayers are not available, good results have been obtained in some cases by pouring the oil solutions on the water.

With ordinary dosages larvicide treatments usually have to be repeated at intervals of 1 to 2 weeks. In certain situations, especially in dense vegetation, dosages of 1 to 2 pounds of DDT per acre may remain highly effective for a month or longer.

The application of larvicides by means of aircraft will be discussed under Area Control of Adults and Larvae.

Adults.—Liquefied-gas aerosols containing pyrethrum, used extensively by the armed services, have been found highly effective against adult mosquitoes. DDT has proved an important adjunct for pyrethrum in these aerosols. The first DDT liquefied-gas aerosols contained the following ingredients: Pyrethrum extract 2 per cent (0.4 per cent pyrethrins), DDT 3 per cent, lube oil (SAE 10) 5 per cent, cyclohexanone 5 per cent, and dichlorodifluoromethane (*Freon-12*) 85 per cent. This formula has recently been modified by L. D. Goodhue and E. R. McGovran, of the Bureau of Entomology and Plant Quarantine, to contain pyrethrum extract 2 per cent (0.4 per cent pyrethrins), DDT 3 per cent, an aromatic petroleum fraction (*APS 202*) 12 per cent, *Freon-12* 83 per cent.

When used in confined places these aerosol formulas are highly effective against mosquitoes. The pyrethrum acts as the principal toxicant, and the DDT adds to the effectiveness of the aerosol against mosquitoes.

Highly concentrated DDT and pyrethrum sprays have recently been developed (Lindquist *et al.* 1945c) which will no doubt have wide application as space sprays. Concentrated sprays containing up to 20 per cent of DDT and 2 or 3 per cent of pyrethrins have been formulated. When they are atomized with proper equipment, including small, compact sprayers recently designed by H. O. Schroeder and A. W. Lindquist, the results are equal to those obtained with liquefied-gas aerosols, using equal dosages of the insecticides.

Sprays containing DDT alone are also effective against mosquitoes when they are properly applied under outdoor conditions. Much emphasis has been placed on the control of mosquitoes outdoors by using various types of sprays producing small-size particles. Ordinary liquefied-gas aerosol bombs and atomizers of the paint-spray type may be employed, but most emphasis has been placed on various special kinds of power equipment. Smoke generators employed by the Army and Navy in applying screening smokes have been modified to produce larger particles, and success is indicated for this type of equipment. The National Defense Research Committee, at Columbia University, working in collaboration with the Bureau of Entomology and Plant Quarantine, developed a special generator. At Urbana, Ill., the same committee has designed a thermal generator for use on the exhaust of trucks and other vehicles.

The employment of DDT as a residual or surface type of spray, as first used by

Wiesmann (1943) against flies, will no doubt represent the most important use of the insecticide in controlling mosquito-borne diseases. DDT may be used as a residual treatment employing oil solutions, emulsions, suspensions, and even dusts. Applications at rates ranging from 10 to 400 mg. of DDT per square foot have given long-lasting effects against adult mosquitoes that subsequently rest on the treated surfaces. In practical tests dosages from 50 to 200 mg. of DDT per square foot of surface area have been used. A 5 per cent DDT spray has been employed in most situations, although the concentration can be varied with the type of surface and the dosage. Tests in Arkansas against *Anopheles quadrimaculatus* Say in 1944, and in Mexico against *A. pseudopunctipennis* Theob. in 1945, have shown that buildings treated at the rate of 200 mg. of DDT per square foot remained almost free of adult mosquitoes for 5 months.

The residual treatment for adult mosquitoes also greatly reduces the larval population. In Arkansas rice fields an average seasonal reduction in larval population of 65 per cent was recorded when all buildings were treated with one application in May. In Mexico a reduction of about 90 per cent of the larvae resulted from the residual treatment. It is believed that in some situations an even greater reduction of larvae may be possible over large or isolated places by using residual treatments on resting places for adults.

DDT applied to vegetation and debris has also given a high degree of control of salt-marsh mosquitoes, *Aëdes taeniorhynchus* (Wied.) and *A. sollicitans* (Walk.) along the coast of Florida for several weeks after application. The DDT suspension appears to be more effective than either oil solutions or emulsions.

Area Control of Adults and Larvae.—There has been great interest in and much effort devoted to the control of both larvae and adult mosquitoes by the treatment of large areas by means of aircraft. Many agencies have studied this problem. Among those participating in this development may be mentioned the Bureau of Entomology and Plant Quarantine, where tests were first begun, the Army Air Forces Board, the Tennessee Valley Authority, the U. S. Navy, and the National Defense Research Committee. Research and development on this aspect of mosquito control also were carried on overseas by a number of military units, both among our forces and our allies.

These studies have shown that the control of both adult and larval mosquitoes can be accomplished by applying relatively small quantities of DDT. Dosages ranging from less than 0.1 pound to 0.6 pound of DDT per acre have been generally employed.

Various types of spray equipment have been designed for planes ranging in size from the Army L-4 (*Piper Cub*) type to the C-47 transports. Various sprays producing particles from 50 to 300 microns in diameter and concentrations of DDT from 1 to 20 per cent have been tested.

In general it has been found that, when the DDT spray is adequately dispersed, good control of adults of both anopheline and culicine mosquitoes can be obtained with fine sprays averaging about 50 microns, as well as with coarse sprays averaging about 300 microns. The fine sprays appear to kill by contacting the insects, whereas the coarse sprays, especially when employed against house-inhabiting *Anopheles*, kill by the contact of the mosquitoes with the treated surfaces. The concentration of DDT apparently is not a critical matter. When equal dosages of DDT were applied, similar results were obtained with sprays containing 5 per cent or 20 per cent. Because of the increased pay load the higher concentrations are much more economical.

The use of airplanes for the control of adult mosquitoes over large areas provides a rapid method of bringing disease epidemics under control, and is especially useful under military conditions. The control of pest mosquitoes in this way is also indicated to be practical. The destruction of both larvae and adults of *Anopheles* over large sections makes them disease-free for several weeks after one treatment. In the meantime, more permanent and economical control measures, such as residual treatments, application of larvicides, and draining, can be instigated.

DDT AND LICE ATTACKING MAN. *Body Louse.*—DDT is highly effective against the three species of lice attacking man, namely, the body louse, *Pediculus humanus corporis* Deg., the head louse, *P. humanus humanus* L., and the crab louse, *Phthirus pubis* (L.). The control of the body louse has been given most attention because of its importance in the

transmission of epidemic typhus. Some of the investigations on the control of this species by the use of DDT have been published by Bushland *et al.* (1944) and Jones *et al.* (1945b).

Two methods of using DDT for the control of the body louse have been developed, the use of powders and impregnation of clothing.

Concentrations of DDT ranging from less than 1 per cent to 10 per cent in several types of powder diluents have been tested. The 10 per cent concentration has been recommended as most practical. Talc and pyrophyllite, as well as other diluents, have been found satisfactory. A single application to the underwear will kill all lice present and will prevent reinfestations for 3 to 4 weeks. The powder can be applied by the individual by means of a small shaker can or by trained operators with hand or mechanical dusters, as worked out by the Army in cooperation with the Rockefeller Foundation. About 1 to 1.5 ounces of the powder is generally recommended. In typhus epidemics, especially in connection with the delousing of diseased patients, the beds, bedding, and all additional clothing within the houses are also dusted thoroughly.

The most effective way to employ DDT for individual protection from body lice is to impregnate the garments. Two methods of impregnating clothing have been found satisfactory. The emulsion concentrate, already mentioned in connection with mosquito control, consisting of DDT, with an emulsifier (*Triton X-100*) and xylene, may be diluted with water to contain 1 or 2 per cent of DDT. The clothing is dipped in this fluid and wrung out to dry. The dosage of DDT should be about 2 per cent of the dry weight of the garment. The volatile solvent method may also be employed for impregnating garments. Any suitable volatile solvent may be used, but *Stoddard Solvent*, a dry cleaning solution, has been found especially satisfactory. The same dosage of DDT mentioned in connection with the emulsion should be used.

Clothing impregnated with proper dosages of DDT will remain louseproof even though washed six to eight times. A material having such persistence was hardly considered possible when investigations on louse control were begun.

Head Louse.—A powder containing 10 per cent of DDT may be used for the control of head lice. The insecticide possesses no ovicidal properties, but if the hair is not washed it will retain sufficient powder to destroy the nymphs as they are hatched. Several hundred school children were treated with a 10 per cent DDT powder, and careful checks after treatment showed no reinfestations. DDT has also been widely used against head lice in Europe and elsewhere in connection with the typhus epidemic control program conducted by the Army.

Dust treatments are not considered entirely desirable for control of the head louse. For this reason several liquid preparations containing DDT have been developed by Eddy (1944, 1946). The following formula (concentrate) is now standard: Benzyl benzoate 68 per cent, DDT 6 per cent, benzocaine 12 per cent and an emulsifier polyoxyethylene derivative of sorbitan mono oleate (*Tween 80*) 14 per cent.

This concentrate (known as the *NBIN* formula) is diluted at the rate of 1 part to 5 parts of water before it is applied. The benzyl benzoate serves as the solvent for the DDT and benzocaine. Benzocaine is an effective ovicide and also alleviates irritation, which usually accompanies louse infestations. Benzyl benzoate was chosen as the solvent because of its scabicidal properties. The concentrate is also an effective scabicide when diluted as recommended for louse control.

A single treatment with the diluted emulsion will destroy all lice and eggs, and the residual action will prevent infestations for about 3 weeks. The treatment has also been employed as a body spray, in connection with the methyl bromide fumigation method of controlling body lice (Latta 1944), to destroy body lice and eggs that sometimes attach to body hairs.

Crab Louse.—The DDT powder and the *NBIN* liquid preparation may be used to control crab lice. The *NBIN* formula, when properly applied, will control an infestation with a single treatment. However, when the powder is used, a second treatment (a week after the first) is generally required.

DDT FOR THE CONTROL OF FLIES.—For the control of houseflies and other related species DDT may be employed both in space sprays (Lindquist *et al.* 1945c) and residual sprays (Lindquist *et al.* 1944, 1945b).

As already mentioned, DDT is an im-

portant adjunct for pyrethrum in the liquefied-gas aerosol. Pyrethrum alone will cause good knock-down of flies, but a high percentage may recover. When DDT is used, however, the flies are killed.

DDT residual treatments have proved highly effective in fly control. Oil solutions, emulsions, suspensions, or dusts may be used. The suspensions have proved especially promising. DDT suspensions are effective on a greater variety of surfaces than the other formulations, and they are more resistant to loss of effectiveness when exposed to ultraviolet light and sunlight.

Dairy barns in Florida were treated with DDT residual sprays as early as July 1943. Over 95 per cent control of flies resulted for at least 4 months. The residual sprays have also been employed successfully in military installations, such as in mess halls, around garbage racks, and in latrines. The spray may be applied with either hand or power equipment. Sprays containing 5 per cent of DDT have been generally recommended, but the percentage of DDT most suitable may vary with the type of preparation, the type of surface to be treated, and the efficiency of the sprayer. A dosage of 100 to 200 mg. of DDT per square foot of surface area is recommended. A paint brush is suggested for treating window and door screens.

In using DDT residual sprays for fly control, it is important to continue sanitation practices and to destroy all possible fly-breeding places. Every effort should also be made to apply the spray to equipment near the source of the fly breeding, as well as to the buildings that are to be protected. In military camps, for example, dairy barns, farm buildings, garbage dumps, or any other possible breeding areas or points of adult fly concentrations in the vicinity should be treated. The fly population can also be reduced by spraying sidewalks, gutters, and store fronts where flies gather. Community action in towns and villages will do much to alleviate the fly nuisance.

DDT has not proved effective against fly larvae, but the treatment of breeding places with DDT will destroy many emerging adult flies.

Airplane applications of DDT are effective against houseflies, but against blowflies (Calliphoridae) the results have not been satisfactory for small areas, apparently because of the long flight range of these species.

DDT TO CONTROL FLEAS.—The same DDT dusts and sprays recommended for body lice will destroy fleas on the person, in bedding, or on loose clothing lying about the home, and will eliminate them from other infested areas. Better distribution of the DDT can usually be obtained with dusts than with sprays.

Flea infestations in homes, dog kennels, chicken houses, and in open yards have been successfully controlled with a single treatment. One gallon of a 5 per cent DDT spray for each thousand square feet of surface is suggested. In buildings the spray should be applied to the floors, and the walls and furnishings should be treated to a height of about 2 feet. On earthen floors the dosage should be increased, since loose dirt may dilute the DDT so that an insufficient amount is available on the surface to give good control.

DDT AND BEDBUGS.—DDT is considered a nearly perfect insecticide for the control of bedbugs, *Cimex lectularius* L. and *C. hemipterus* F. Extensive laboratory and practical tests have fully demonstrated the value of the insecticide for this purpose (Madden *et al.* 1944, 1945a, Daniels 1945). The first large-scale practical test in this country for the control of any insect was conducted on the bedbug.

DDT sprays are generally recommended for bedbugs, but DDT dusts are also effective. The spray is usually applied with pressure-type or knapsack sprayers, or with power equipment. Other equipment may be used, including an ordinary *Flit* gun, paint sprayer (either hand- or power-driven), or a paint brush. If atomized sprays are used, the sprayer should be held close to the surface to be treated to obtain a good deposit with a minimum loss of spray material.

A 5-per cent DDT spray is recommended, either in kerosene solution or in aqueous emulsion. The spray should be applied thoroughly to the entire bed, including the springs, bedstead, and mattress. Special attention should be given to the joints and corners, which furnish favorite hiding places for bugs, as well as to cracks, crevices, and other favorite hiding places. The walls should also be sprayed to a height of about 6 feet. About 100 ml. of spray is required for the treat-

ment of a single bed. About 3 gallons of spray is required to treat the beds and walls of a large (70-man) army barracks. A single treatment, as described, has given complete control of bedbugs for over a year in some experiments.

The use of the residual spray principle of controlling insects is especially applicable to bedbugs. Experience with ordinary sprays has shown that it is almost impossible to contact all bugs in infested quarters because of their well-concealed hiding places. No doubt the DDT spray, when thoroughly applied, actually contacts and kills outright a high percentage of the bugs, but the residual deposit eventually destroys those remaining.

SUMMARY.—The use of DDT for the control of some of the more important insects affecting man is discussed. The insects included in the discussion are mosquitoes, lice, flies, fleas, and bedbugs. DDT is no doubt one of the most effective and desirable insecticides known for the control of these insects and for the control of diseases transmitted by them.

DDT can be employed as a dust, solution, emulsion, or suspension, and may be applied with many types of equipment.

Mosquitoes, both larvae and adults, are effectively controlled with DDT. With ground equipment a dosage of 0.1 pound of DDT per acre as a dust of oil solution is generally recommended, although lower dosages are effective against anopheline larvae; certain culicine species may require higher dosages. Airplane sprays have been successfully used in controlling mosquito larvae, especially anophelines.

DDT has provided very effective methods for controlling adult mosquitoes. It is useful alone or in combination with pyrethrum in space sprays or aerosols. Its application as a residual-type spray against adult mosquitoes, however, will probably be of most value in controlling mosquito-borne diseases. By the use of DDT sprays applied from airplanes or special ground apparatus, adult mosquitoes as well as larvae can now be controlled outdoors over large areas.

All three species of lice attacking man are effectively controlled with DDT. A 10 per cent DDT powder can be used against body lice, head lice, and crab lice. Various special treatments have been developed, however, which are more effective or more desirable. Clothing impregnated with DDT will provide control of body lice even after it is washed six to eight times. Special liquid formulas have been developed which are highly effective against head lice and crab lice.

The use of DDT in ordinary sprays and aerosols is highly effective against flies. As a residual treatment, however, it has provided a greatly needed adjunct to ordinary sanitary measures.

DDT is an effective agent for controlling fleas on the person and eliminating them from infested quarters.

DDT has also provided a highly effective method for controlling bedbugs. Sprays applied to beds and infested quarters will not only destroy the entire infestation but will prevent reinfestations for many months.—3-5-46.

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PEST CONTROL SHORT COURSE

What is apparently the first short course dealing with the pest control problems encountered by sanitary inspectors and other public and private agencies interested in work in the general field was held April 29 to May 3, 1946, at Purdue University.

The course was sponsored by the University in cooperation with the U. S. Fish and Wildlife Service and the U. S. Public Health Service and the Indiana State Board of Health.

There were 87 registrations including representatives from 17 different states and a very successful week is reported.

Not the least important phase of such a conference, from the standpoint of the entomologist, is the fact that it was given through the auspices of an entomology department. That fact is bound to suggest to employers that entomological training for sanitary inspectors and supervisors of such work, is a valuable asset and the end result should be more jobs for entomologists and, we are convinced, better service for the public.

CAPTAIN W. DOYLE REED

Mr. W. Doyle Reed, during the war a captain in the Corps of Engineers, in charge of insect and rodent control work was placed on terminal leave by the Office of the Chief of Engineers on June 13, 1946. Mr. Reed was appointed by the Chief of Engineers in a civilian capacity as Chief of the Insect and Rodent Control Section, on June 14, to direct Army-wide policies and procedures in pest control at military installations. The work will include posts, camps, and stations in the continental United States and at overseas installations. Mr. Reed enlisted in the Army as a volunteer in July 1942 and after basic training at Camp Lee, Virginia and Camp Sibert, Alabama was commissioned after completion of officer candidate school at Edgewood Arsenal, Maryland in December 1942. Captain Reed was detailed in the Sanitary Corps for a brief tour of duty at Tilton General Hospital, Fort Dix, New Jersey and later detailed to the Office of the Chief of Engineers for the duration of the war.

DDT to Control Insect Pests Affecting Livestock

W. G. Bruce and E. B. Blakeslee, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

Insect pests of domestic animals have become a serious problem in recent years and are important factors affecting the success of the livestock industries in the Southeastern States. For example, some stockmen have discontinued operations because of the ravages of screwworms. Other localized infestations of horn flies, cattle lice, deer flies, horse flies, and mosquitoes have made drastic inroads upon, or completely wiped out the margin of profit. The control of these pests affecting livestock may, therefore, determine the success or failure of many livestock enterprises in this area.

The insect and arachnid pests of economic importance to the livestock producers of the Southeast may be listed in the following descending order of importance: Screwworms, *Cochliomyia americana* C. and P.; horn flies, *Siphona irritans* (L.); long-nosed cattle louse, *Linognathus vituli* (L.), other cattle lice, *Haematopinus eurysternus* Nitz., and *Bovicola bovis* (Nitz.); deer flies and horse flies, many species, including *Chrysops* spp., *Tabanus lineola* F., and *Tabanus atratus* F.; Gulf Coast tick, *Amblyomma maculatum* Koch; stableflies, *Stomoxys calcitrans* (L.); cattle grubs, *Hypoderma lineatum* De Vill.; fresh-water mosquitoes, mostly *Culex quinquefasciatus* Say, *C. nigripalpus* Theob., *Psorophora confinnis* (L.-Arr.) and *P. ciliata* (F.); salt-marsh mosquitoes, *Aëdes sollicitans* (Walk.) and *A. taeniorhynchus* (Wied.); houseflies, *Musca domestica* L.; hog lice, *Haematopinus adventicius* Neum.; and horse bots, *Gasterophilus* spp.

Obviously the activities of these pests are more or less seasonal and many are localized; however, some are active throughout the year in southern Florida. Their incidence and relative abundance are dependent upon meteorological factors, and upon the availability of breeding media and host animals.

The effectiveness of the new insecticide DDT against the insects affecting military and civilian personnel during the war indicated its possible use against insect pests of livestock. Therefore, small-scale tests were made in 1944 and 1945 to determine the effect of DDT on some of the insects and its toxicity to the host. After a number of preliminary tests had been conducted, involving about 3000 head of livestock (mostly cattle), a large-scale test was made in 1945 wherein about 26,000 head of livestock and about 120 dairy barns and other buildings were treated with various concentrations of DDT.

The primary purpose of this paper is to present information relative to the large-scale tests, but a discussion of the preliminary tests, including methods, equipment, and results, is considered to be important because they led up to and justified the large-scale tests.

Preliminary Tests.—The cattle used in the preliminary tests ranged from half-wild native stock to herds of purebred animals kept under fence, and represented a cross section of the cattle industry in the southeastern United States. In most cases the horn fly was the principal pest, but in one instance salt-marsh mosquitoes, deer flies, and horse flies predominated in importance. Except for one test in 1944, stableflies were of only secondary importance.

In addition to the cattle spraying, 14 dairy barns were treated with DDT once or twice during the season for housefly control. These barns were located where frequent checks could be made to determine fly populations.

Materials.—One test was conducted in 1944 with an emulsion prepared from a stock concentrate of 25 per cent of DDT, 68 per cent of xylene, and 7 per cent of polyethylene glycol phenylisoactyl ether (*Triton X-100*). The sprays used in the 1945 tests were prepared from two DDT formulations—(1) emulsions, prepared from a stock concentrate of 25 per cent of DDT, 65 per cent of commercial xylene, and 10 per cent of *Triton X-100;* and (2) water suspensions, prepared from a commercial water-dispersible, or wettable, powder containing 50 per cent of DDT.

Methods of Application.—The DDT was applied both as dips and as sprays. The methods employed depended to some ex-

tent upon the cattle-handling facilities on the ranch. Dipping was done in vats of conventional design, with a capacity of about 3000 gallons, and filled to a depth that permitted complete submersion of the animals. Spray applications were made in chutes and in small corrals. The most satisfactory method was pen spraying in which 15 to 30 animals were restrained in a small pen (Fig. 1). A catwalk for the operator was usually built along the outside of the chute or corral. A third type of treatment consisted in wading the animals through a shallow vat containing about 18 inches of material and at the same time spraying the back and sides of the animals as they passed through. Most of the sprays were applied with an adjustable, long-range orchard gun operated from a small power sprayer under a pressure of about 300 to 350 pounds per square inch. This type of spray gun was found to be more satisfactory and less wasteful of spray material than the broom-type nozzle. Disc orifices used in the gun ranged from 0.04 to 0.06 inch in diameter depending on the volume of spray required.

Dairy-barn applications were made with the machine which was used in livestock spraying, except that the pressure was reduced to 100 to 125 pounds per square inch and a quarter-inch extension rod was substituted for the orchard gun. The most efficient nozzle for barn spraying was found to be a flat atomizing type giving a fan-shaped delivery of uniform pattern at an angle of 80°.

FIG. 1.—Spraying cattle in pens, Orlando, Fla.

Stableflies.—In most of the tests stableflies were not present in sufficient numbers to indicate the control to be expected from DDT under outbreak conditions. One such test was made, however, on a ranch in central Florida in 1944, in which a serious outbreak had developed from breeding in large accumulations of citrus waste used as feed. The fly population in April was enormous; as many as 250 flies were observed on day-old calves and many times that number on full-grown animals. Older animals were unable to feed during the day, and calves were starving because the mothers refused to stand for them to nurse.

In cooperation with personnel of the Orlando laboratory of the Bureau of Entomology and Plant Quarantine, the senior author arranged for treatment of the cattle with DDT. Since stableflies feed mostly on the legs and lower parts of the animal's body, thorough treatment of these areas was especially important. A concrete wading vat 6 feet long, 18 inches wide, and 18 inches deep was charged with 100 gallons of 2 per cent DDT emulsion. On April 28 approximately 300 cows and 185 calves and yearlings were waded through this vat, and sprayed over the back with the same concentration of DDT emulsion as used in the vat. All near by resting places of the flies, such as open sheds, fence posts, bases of trees, weed patches, and corral fences, were also sprayed. The fly outbreak was immediately and effectively checked. Only 6 or 7 flies per animal were observed on the cattle 17 days after the insecticide was applied. The owner stated that for most of the time subsequent to treatment the number of flies had been even less than 6 or 7. The citrus pulp still contained enormous numbers of pupae and was evidently producing large numbers of flies. The period of control resulting from one application was conservatively estimated at 2 weeks, but from the amount of active breeding it was probably effective much longer, as there was no further trouble from stableflies that season.

Horn Flies.—Pre-treatment populations of the horn fly in 1945 ran as high as 10,000 per head in extreme cases, and probably averaged 1500 to 2000 per head for all animals treated.

In one test in South Carolina 90 Hereford cattle were sprayed on April 19 with an average of 1 pint per head of 2.5 per cent DDT emulsion. The pre-treatment population of horn flies ranged from 500 to 3000 per head. On May 9, 20 days later, the infestation ranged from 0 to 50 per head. A second application of the same spray, about a half-pint per animal, was made on May 9, after which horn flies remained well below nuisance numbers for 50 days more.

In another test in central Florida two lots of cattle about equally infested with horn flies were kept in separate pastures 2 miles apart. One lot of 430 head was sprayed, and the other lot of 250 head was left untreated. The treated lot was sprayed on April 26 and again on May 17 with 1 pint per head of an emulsion containing 2.5 per cent of DDT in the first application and a half-pint per head in the second application. The pretreatment horn fly population was estimated at 1500 to 2000 per animal. No further treatments were made on cattle in the treated lot, and horn flies remained well below nuisance levels for the rest of the season while the cattle in the control pasture maintained a heavy population. Owing to the occasional small turnover of feeder cattle on this ranch, it was agreed that all replacements turned into the test pasture should be sprayed. Therefore, the few animals that were subsequently released in this pasture were treated in accordance with this arrangement. Apparently this aided in maintaining the control established by the two early treatments.

Dipping in a DDT emulsion of low concentration did not give such long periods of effective protection from horn fly as spraying with higher concentrations. In a parallel test of the two methods, one lot of cattle was dipped in an emulsion containing approximately 0.2 per cent of DDT, and another lot was sprayed with a 2 per cent emulsion. Both lots were kept in isolated pastures during the test. Two weeks after the first treatment the dipped lot averaged from four to five times as many flies as the sprayed lot.

Housefly Control in Dairies.—Fourteen dairy establishments, with a total of about 171,000 square feet of interior surface, were treated with DDT sprays during the season. Both water suspensions and emulsions were used, with a spray concentration of 2.5 per cent of DDT in all the tests. The surface treated per gallon of spray ranged from 187 to 490 square feet, and averaged about 450 square feet. Biweekly counts of fly populations were taken in each establishment subsequent to spraying, and these were compared with counts in untreated dairies in the same area of similar structure and comparable fly sanitation.

It was found that the interior finish of the main dairy building and the fly sanitation maintained on the premises were in most cases the limiting factors in the degree of control obtained. Applications of DDT emulsion in dairies with ceiled and painted interiors gave much longer protection than those made in barns with

open ceilings and rough lumber finish. In 10 dairies, 4 of which were ceiled and painted inside and 6 were of open ceiling with unpainted wood frames and metal sides and roof, the finished interior retained effective control for an average of 173 days, and the unfinished interior for an average of 73 days, from a single application.

Several factors apparently contributed to the difference in the results obtained in the two types of structure. Usually the better type of building was accompanied by better sanitation. In one of the painted and ceiled barns, although the fly sanitation was extremely poor, good control was obtained. In the buildings with rough lumber interiors the surface residue was undoubtedly reduced by absorption of some DDT into the wood when emulsions were used. In two barns with painted ceiled finish and good fly sanitation the flies were effectively controlled for the entire season with one application, made in one case on March 5 and in the other on April 12. Neither barn received an excessive amount of spray. At the other extreme in one barn with open ceiling rough lumber construction, and poor fly sanitation only 33 days of effective control was obtained from one application. Partial treatments in which only outbuildings containing infested media were treated did not result in satisfactory control. With badly infested outbuildings the treatment of the dairy barn alone did not result in effective control, but treatment of the entire premises was required. With good fly sanitation, good results were obtained by the treatment of the dairy barn only, when that structure was ceiled and painted inside.

Treatment of infested manure piles with DDT sprays as a supplement to barn spraying was only partly effective and is not considered of much practical value.

LARGE-SCALE TESTS.—The preliminary tests with DDT emulsions showed that the DDT was effective for controlling horn flies, stableflies, and houseflies. There was no apparent toxicity to the animals treated, although the xylene caused considerable irritation as evidenced by a conspicuous nervousness for about half an hour after the emulsions were applied. Emulsions cannot be considered entirely harmless to animals, however, because of the possible absorption of the dissolved DDT through the skin.

By midsummer of 1945 a water-dispersible DDT powder was made available for tests. In this form the DDT is simply suspended in water; hence it cannot be absorbed through the skin and, consequently, is much safer for use on domestic animals.

It was decided, therefore, to make some large-scale tests with water-dispersible DDT for the purpose of determining the efficacy and practical dosages required to control various insect pests affecting livestock, as well as the effect on the general welfare of the treated animals and the advantages of community cooperation in an insect-control program.

Tests in Orange County.—Orange County, located in central Florida, was one of the four counties selected for these tests.

The tests were planned by the Bureau of Entomology and Plant Quarantine in cooperation with the Florida Extension Service, the Florida Agricultural Experiment Station, E. I. du Pont de Nemours and Company, and the local cattlemen's association.[1] Approximately 132 stockmen and farmers, representing ownership of over 15,000 head of livestock, cooperated. Most of the cooperators were located in a 350-square-mile area in which practically every animal was treated with DDT.

Spray operations were started on August 4, 1945, and completed in about 10 days. Except for 800 head of beef cattle, which were dipped in a 0.23 per cent DDT suspension and redipped in 3 weeks, all animals were sprayed with a single application of a suspension containing 2.3 per cent of DDT (2 pounds of the powder to 5 gallons of water). All barns and sheds were also sprayed with this suspension. One small portable spray rig and three commercial spray rigs were used in most of the spray applications. Knapsack sprayers were used on small numbers of livestock and on small sheds. Applications were at the rate of 1 to 1.5 pints per animal, and to buildings at the rate of 1 gallon per 300 square feet. Most of the cattle were sprayed in pens, and the spray was directed from opposite sides of the pen to insure adequate coverage.

[1] Particular acknowledgement of assistance is made to K. C. Moore, county agricultural agent; L. O. Gratz, assistant director, Florida Agricultural Experiment Station; Carl W. Peterson, E. I. du Pont de Nemours and Company; and A. L. Smith and C. C. Skipper, Bureau of Entomology and Plant Quarantine.

The total number of livestock sprayed and dipped in Orange County was 15,516. This included 10,326 beef cattle, 4825 dairy cattle, 139 horses, 163 hogs, 43 milch goats, 2 mules, 7 dogs, and 11 unspecified animals. Fifty-five dairy barns and approximately 50 other farm buildings, including a large hog pen, were sprayed. A total of 1696 pounds of the water-dispersible powder, containing 50 per cent of DDT, was used in these tests.

The horn fly was the most abundant and most annoying pest of cattle and horses. Infestations ranged from 1000 flies per head to as high as 15,000 on some bulls, with an average estimated infestation of at least 3000 per animal on all cattle. As many as 500 horn flies were found on some horses. Stableflies were not abundant, and only a few localized light infestations were observed. Fresh-water mosquitoes were abundant and very annoying to man and animals. Deer flies and horse flies were troublesome on a few ranches. Screwworms were active, and 1 per cent or less of the animals in that area were infested. Few cattle lice were observed. Moderate infestations of goat lice were found on a herd of milch goats. Houseflies were abundant in most barns, and extremely heavy infestations were noted in several barns and around hog pens. Salt-marsh mosquitoes are not troublesome in this area. Gulf Coast ticks were active at this season of the year, and some heavy infestations were noted. Cockroaches were abundant in most dairy barns. The combined attacks of horn flies by day and mosquitoes by night was the most serious annoyance to livestock in Orange County.

A definite decline in the horn fly populations was conspicuously evident immediately after spraying. Houseflies in dairy barns were practically eliminated in 24 hours. The effect of DDT on other insects was less quickly determined.

Animals and barns were checked during the 2-week period of September 17 to October 2, 6 weeks after the beginning of the spraying operations. Every stockman was completely satisfied with the tests. There were no criticisms of the tests and no report of any sickness of livestock due to the sprays. While excellent results were obtained in all tests, the most effective and lasting were those in the interior of the 350-square-mile area.

Horn flies were almost completely eliminated, and an average of less than 1 per animal was found except on cattle near the perimeter of the sprayed area, which were in close proximity to unsprayed animals, and on infested animals which were added to the herd.

Houseflies around dairy establishments were effectively controlled even though the sanitation of some dairies was very poor. The largest number of houseflies found in any one dairy was 22, but in most dairies it was difficult to find as many as 5 houseflies. For 3 weeks houseflies were almost completely controlled around hog pens, where hogs were fed garbage, although reinfestations were brought in daily on garbage trucks.

Stableflies were not numerous before spraying, but were extremely scarce 6 weeks thereafter.

Fresh-water mosquitoes, which had been exceedingly abundant and annoying to both man and animals, were completely exterminated.

The control of deer flies and horseflies was difficult to determine. Many stockmen claimed a great reduction and in some cases complete eradication of these flies, while others were doubtful. It is the writers' opinion that DDT could not be considered an effective insecticide for *Tabanus atratus* but that it probably reduced the populations of *T. lineola* and *Chrysops spp.* by about 50 per cent.

Lice were observed in the brush of the tail of two cattle which were sprayed but none on any of the other cattle.

No live lice were found on a herd of milch goats after spraying, but a large number of dead lice were observed.

Roaches were killed wholesale in dairy barns and, except for an occasional moribund individual, none were observed 6 weeks after spraying.

The general condition of all beef cattle and of most dairy cattle was improved. Increased milk production in beef cows was reflected in the increased growth and improved condition of their calves. Some dairymen had been practicing good fly control, and little noticeable change was apparent among these cattle.

Beef cattle owners estimated gains of a few pounds to 100 pounds per animal. It is conservatively estimated that a gain of 40 pounds per animal resulted from the spray.

In connection with weight gains of beef

cattle it is of interest to note a report from our cooperators, W. G. Kirk, vice-director in charge, and E. M. Hodges, associate agronomist, Range Cattle Experiment Station at Ona, Florida.

"The DDT (emulsion containing 2.5 per cent of DDT) was first used to control horn flies on July 30, 1945. Not more than one pint of the mixture was used to spray each animal. . . . The 36 steers first sprayed were in 10 groups. . . . The steers were weighed individually at weekly intervals as they were changed to duplicate pastures. . . . The average weight change for the week before spraying ranged from a loss of 17 pounds to a gain of 11 pounds while for the week after spraying it was from a gain of 11 to 44 pounds. The greatest individual weight change for the week after the spraying was 80 pounds. Differences in gains cannot all be attributed to the use of DDT in the control of horn flies. Part of the variations in gains with the 10 groups before and after spraying was due to the fertilizer treatment given the pastures, response of the cattle on the duplicate pastures, and temperature and rainfall during the weekly periods. The one spraying kept the steers practically free of horn flies for 3 weeks.

"Later on in the summer *Deenate* (water-dispersible powder containing 50 per cent of DDT), one pound to 2.5 gallons of water, was used to spray the main herd. Although the animals are weighed every 28 days there was no adequate check on the effect of fly control on the weight of individuals. The spraying kept the cattle free of horn flies for at least 3 weeks. The breeding herd is in better condition and calves are heavier than in previous years. The control of the horn fly by the use of DDT, has contributed to the maintenance of the breeding herd in good condition."

The milk production of dairy cattle is below normal from May until October, the lowest figure being reached in July or August. Production records from owners of 1329 dairy animals (not all cattle in production) showed that they were producing 1314.5 gallons of milk daily before spraying and 1357 gallons 2 weeks later, a gain of 42.5 gallons per day. The manager of one of the principal milk depots in this area reported that the usual seasonal decline in milk production was halted immediately by the spraying, and that there was an average gain of 200 gallons of milk per day from the 23 dairies delivering milk to his plant. The county agent pointed out that, while there was a slight reduction in milk production for Orange County as a whole, the production per cow was 5.8 per cent higher than the average for the state. This information was obtained from the milk-production reports of the state AAA office, which were made in connection with the dairymen's applications for milk subsidies. This means an additional production of 28,216 gallons of milk valued at $11,850.

Tests in Osceola County.—After the spray operations in Orange County were completed, similar tests were made in the adjoining Osceola County, except that a 0.5 per cent DDT suspension was used. In a 50-square-mile area adjacent to the sprayed area in Orange County 33 of the stockmen were organized.[2] This made a contiguous area of 400 square miles in which practically all domestic animals were treated with DDT. In Osceola County 7422 head of livestock were sprayed, which included approximately 7257 beef cattle, 100 dairy cattle, 45 horses, and 20 unspecified animals. Two dairy barns and three sheds were sprayed with the same material. Two commercial spray rigs completed the spray operation in 5 days.

The insect pests were of the same species and the same relative abundance as in Orange County, except for a higher average infestation of horn flies, estimated at 4000 flies per animal.

When the results were checked 1 month after the final spraying, horn flies were completely eliminated for about 3 weeks. Horn fly populations then started to build up, but the normally rapid build-up was greatly impeded by meteorological conditions. Most of the area where tests were made was located in the Kissimmee Valley, a large part of which was inundated following the hurricane on September 16. The cattle droppings, in which the horn flies breed, were completely disintegrated by the flood waters, thus eliminating a potential crop of horn flies.

Opinions were divided as to the effect of the spray on deer flies and horse flies, but most of the stockmen recorded little

[2] The county agricultural agent, June Gunn, directed this work.

or no protection from these pests.

Fresh-water mosquitoes were reported to be greatly reduced in numbers for about 3 weeks, but the control was not so effective and permanent as in Orange County.

Apparently the 0.5 per cent DDT suspension was effective against houseflies in dairy barns for 1 month or less. A build-up of these pests was in progress at the time of checking.

No cattle lice have been observed since the cattle were sprayed.

Stableflies were not present in sufficient nunbers before the spraying to determine the effect of the spray on these pests.

Milk production at the two dairies remained about the same, although a slight increase was reported by one dairyman.

The general condition of all cattle was improved, and cattlemen estimated an average gain of 50 pounds per head on beef cattle during the month following spraying.

Tests in Brevard County.—Four tests were made in Brevard County, adjoining Orange and Osceola on the east, in which 1112 beef cattle and 40 dairy cattle were sprayed with a water suspension containing 1 per cent of DDT. One dairy barn was sprayed with a 2 per cent DDT suspension. All applications were made with a knapsack sprayer at the rate of approximately 1 pint per animal and 1 gallon per 300 square feet of barn surface. The most important insect pests in this area were horn flies (about 1000 per animal), deer flies, horse flies, and salt-marsh mosquitoes.

Horn fly control was about the same as in Osceola County, where a 0.5 per cent DDT suspension was used with effective control for 2 to 3 weeks, followed by a rapid build-up.

Tabanus atratus was abundant, averaging 4 flies per animal. No control of this pest was noted. Nor did this spray have any noticeable effect on *T. lineola* and *Chrysops* spp., both of which were abundant.

One dairyman reported a drastic reduction in the population of salt-marsh mosquitoes after spraying.

Excellent housefly control was obtained in the dairy barn that had been sprayed.

Tests in Lake County.—Other tests on approximately 2000 head of dairy and beef cattle and 4 dairy barns, with a suspension containing 2.3 per cent of DDT, were made in Lake County, adjoining Orange County on the west and north. All applications were made with a knapsack sprayer. These treatments gave 100 per cent control of horn flies on herds for 5 to 7 weeks and the usual excellent control of houseflies in barns.

SUMMARY.—In 1944 and 1945 observations were made on the effectiveness of DDT insecticides against several species of insects affecting livestock in the southeastern United States. Preliminary tests were conducted on approximately 3000 head of livestock and in 14 dairy barns. A serious outbreak of stableflies, *Stomoxys calcitrans* (L.), in central Florida was brought under control by passing animals through a wading vat containing a 2 per cent DDT emulsion and spraying their backs with the same emulsion. In tests in South Carolina and Florida two applications of 2.5 per cent DDT emulsion sprayed on cattle kept hornflies, *Siphona irritans* (L.), well below nuisance numbers for the rest of the season. Dipping the animals in a 0.2 per cent emulsion was less effective than spraying with a 2 per cent emulsion. One application of a spray containing 2.5 per cent of DDT, in both emulsion and water suspension, to the interior of dairy buildings controlled houseflies, *Musca domestica* (L.), for the entire season where the interior was painted and ceiled, and where good fly sanitation was practiced.

In large-scale tests in 1945 approximately 26,000 head of livestock and 120 dairy barns in Orange, Osceola, Brevard, and Lake Counties, were treated with water suspensions prepared in various strengths from water-dispersible DDT powder.

Dipping of cattle in a 0.23 per cent DDT suspension gave complete control of horn flies for 10 days to 2 weeks. There was no apparent effect on other pests, except possibly on cattle lice.

Complete horn fly control was obtained for 2 to 3 weeks by spraying with a 0.5 per cent DDT suspension. It was somewhat effective against fresh-water mosquitoes, effective for a month or less against houseflies in barns.

A 1 per cent DDT suspension applied as a spray gave control of all insects about the same as a 0.5 per cent suspension.

A 2.3 per cent DDT suspension gave

100 per cent control of horn flies for 4 to 7 weeks, was very effective against houseflies for more than 3 months when sprayed on barns, and was effective for more than 3 weeks against houseflies in hog pens. This suspension was very effective against stableflies when applied to livestock and to resting places of the flies. It was 100 per cent effective against fresh-water mosquitoes when applied as a spray to livestock and buildings, and was effective against cockroaches in barns. The same suspension was apparently effective for the control of cattle lice, if the animal was thoroughly sprayed. This suspension reduced screwworm fly population, and was effective against the Gulf Coast tick.

No apparent injury resulted from the use of DDT on these animals.

It is conservatively estimated that the DDT sprays were responsible for a minimum gain of 700,000 pounds of beef and 30,000 gallons of milk, during the month following the spray applications.—4-23-46.

Observations on Tick Repellents

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Experiments with various materials as tick repellents have been conducted at Savannah, Ga., and at Camp Bullis, Texas, during the last few years.[1] Most of these materials had already shown promise as insect repellents.

EXPERIMENTS AT SAVANNAH.—Preliminary tests were made at Savannah to demonstrate the best method of testing repellents against ticks. Nymphs and adults of the lone star tick, *Amblyomma americanum* (L.), were used. Tests in which repellents were evaluated by the number of ticks that crossed a treated band of skin or clothing, or by the number that attached when confined over an area of treated skin, were inconsistent and hence unsatisfactory. The most consistent results were obtained when the repellents were applied to the skin or clothing of persons who walked, stood, or sat with untreated persons in tick-infested areas, and the ticks that attached to the treated and untreated persons were counted.

Early in the study it was found that repellents were more effective when applied to the clothing than when applied to the skin. In later tests, therefore including those reported here, treatments were applied to the clothing only.

The materials that offered the most promise in the first tests were *Indalone* (α, α-dimethyl-ά-carbobutoxy-γ-dihydropyrone), dimethyl phthalate, *Rutgers 612* (2-ethyl-1,3-hexanediol), pyrethrum, bisethylxanthogen, and DDT. These materials were tested more completely by comparison with untreated checks and with each other. Under outdoor conditions the subjects were exposed to naturally heavy tick infestations, or to infestations artificially established in a favorable environment. The results of some outdoor tests are presented in table 1. Except as noted in the table, the entire clothing was sprayed with the repellent.

The results with bisethylxanthogen were not consistent, as the material appeared to be more effective a week after application than when freshly applied. DDT was not effective in pyrophyllite, had very little effect in kerosene, and in benzyl benzoate and dimethyl phthalate was no more effective than the solvent alone. The results with benzyl benzoate were not entirely consistent, but indicated that the material gave a reasonable degree of control. The only instance of complete protection was with this material. Dimethyl phthalate was reasonably effective only when freshly applied. *Indalone* was effective when freshly applied to the entire clothing or to the openings of the clothing, and more than 70 per cent effective after 14 days. In these outdoor tests pyrethrum with *IN-930* was about as good as *Indalone*.

Similar tests were conducted indoors, during the winter, against adults of the black-legged tick, *Ixodes ricinus scapularis* Say, as well as against nymphs and adults of *Amblyomma americanum*. The ticks were confined on meadow sods in a pen, and exposed to high temperatures and a gradually increasing photoperiod. Treated and untreated subjects, wearing short

[1] H. O. Schroeder and L. A. Mayer assisted in some of the experiments.

Table 1.—Attachments of ticks (*Amblyomma americanum*) to men wearing clothing treated with various materials. Outdoor tests, in infested areas, Savannah, Ga., 1943.

Treatment	Date Repellent Applied to Clothing	Date Clothing Tested	Number of Ticks Attached to— Treated Subject Nymphs	Treated Subject Adults	Untreated Subject Nymphs	Untreated Subject Adults
	April	*April*				
DDT:						
20% in benzyl benzoate	13	13	8	3	14	1
		16	2	1	4	1
20% in dimethyl phthalate	14	14	2	2	14	0
5% in kerosene	15	15	9	1	14	1
20% in pyrophyllite	15	15	23	4	14	1
Bisethylxanthogen, 5% in *Deobase*[1]	14	14	11	2	14	0
		17	4	0	72	6
		23	3	1	114	10
Dimethyl phthalate	14	14	2	2	14	0
		17	43	13	72	6
Benzyl benzoate	15	15	0	0	14	1
		19	14	5	247	24
	20	20	8	4	26	2
		23	14	1	114	10
Pyrethrum 1% plus *IN-930*,[2] 2% in Deobase	20	20	3	1	26	2
		23	14	1	114	10
Indalone	13	13	1	0	14	1
		16	2	1	4	1
		19	26	9	247	24
	20	20	2	0	26	2
		22	3	4	218	57
Indalone (applied only to margins of openings of clothing)	8	22	53	7	218	57
	22	22	4	3	218	57

[1] A refined kerosene.
[2] N-isobutylundecylenamide.

trousers, exposed themselves to the ticks by standing in the pen. As the grass in the pen was short, all ticks had to cross the socks to reach the host. For this reason only the socks were treated. The materials tested were dimethyl phthalate, *Indalone*, *Rutgers 612*, pyrethrum in dimethyl phthalate, and pyrethrum in *Deobase*. Each material was tested on the day it was applied to the socks and 1, 2, and 3 weeks later. Between tests the treated socks hung in an open room.

The numbers of ticks attaching to each person in each test are listed in table 2. *Indalone* gave complete protection against all three types of ticks during the entire 3 weeks, and must accordingly be considered the best. The characteristic odor of the material was still strong on the socks after 2 months, and the reaction of the ticks on reaching the treated clothing was more immediate than with any other repellent. However, most persons using *Indalone* find the odor objectionable.

Dimethyl phthalate was almost as satisfactory as *Indalone*, giving complete protection when fresh, 2 weeks, and 3 weeks old, but not when 1 week old. At the time of the last test, however, only one tick attached to the check subject. Dimethyl phthalate has the advantage of being free of objectionable odor.

Rutgers 612 was effective when fresh, but at 1 week permitted a few ticks of each type to attach. It gave complete protection when 2 weeks old, but at this time the number of ticks attaching to the untreated subject was lower than before, and it was ineffective at the last test.

Pyrethrum in dimethyl phthalate was

Table 2.—Degree and persistence of protection given by materials tested as tick repellents. Indoor tests, Savannah, Ga., 1943.

Date of Report	Numbers of Ticks Attached to Men Wearing Treated Socks[1]					
	Dimethyl Phthalate	Indalone	Pyrethrum-Dimethyl Phthalate	Rutgers 612	Pyrethrum-Deobase	Check (No Treatment)
Jan. 26	0–0–0	—	—	—	—	18–17–6
28	—	—	0–0–2	—	—	11–19–2
29	—	—	—	0–0–0	—	44–28–3
30	—	0–0–0	—	—	—	6–54–2
Feb. 1	—	—	—	—	0–0–0	21–21–3
3	0–1–0	—	—	—	—	9–45–3
4	—	—	0–1–1	2–2–1	—	9–35–3
5	—	0–0–0	—	—	—	18–70–1
8	0–0–0	—	—	—	0–0–2	5–36–0
10	—	—	0–0–1	—	—	11–32–2
12	—	0–0–0	—	0–0–0	—	3–15–0
15	0–0–0	—	—	—	0–0–0	0– 0–1
17	—	—	0–1–0	—	—	2–21–3
19	—	—	—	0–3–1	—	0– 8–1
20	—	0–0–0	—	—	—	0–19–1
21	—	—	—	—	1–6–7	1– 7–3

[1] The first figure in each observation represents adults of *Ixodes scapularis*, the second, nymphs of *Amblyomma americanum*, and the third, adults of *A. americanum*. The first date for each material is the date it was applied.

effective against adults of *Ixodes scapularis* in all four tests, and against nymphs of *Amblyomma americanum* in two tests, but was not effective against adults of *A. americanum* even when fresh.

Pyrethrum in *Deobase* was effective against all three types of ticks in the first test, but allowed adults of *Amblyomma americanum* to attach when it was 1 week old. The test at 2 weeks was inconclusive, as only one tick attached to the check subject, and at 3 weeks the material was completely ineffective.

Other tests were conducted under various conditions of exposure and treatment, but were too dissimilar to permit tabulation. The results obtained agree with those presented in the tables. The repellents were more effective under artificial conditions than under natural ones, but *Indalone* and dimethyl phthalate were always of some value.

EXPERIMENTS AT CAMP BULLIS.—In July 1943 experiments were conducted by H. O. Schroeder and the senior author at Camp Bullis, an adjunct of Fort Sam Houston, Tex. The experimental subjects were troops performing their normal field duties. Tick infestations were light, even on untreated subjects, but the results indicated that *Indalone*, dimethyl phthalate, and rotenone-sulfur dust reduced tick attachments for a few days.

Experiments under more favorable conditions were conducted at Camp Bullis in April 1944. At this time ticks were more abundant, the troops spent more time in bivouac areas, and the average infestation of the men was higher. The studies were carried out by the senior author and H. M. Brundrett of the Bureau of Entomology and Plant Quarantine, and James M. Brennan of the Post Surgeon's Office, Fort Sam Houston.

In the following records tick counts include both nymphs and adults of *Amblyomma americanum*.

The men involved in these experiments were members of one of three units, which are designated here as A, B, and C. Two repellents, dimethyl phthalate and 6-2-2 (dimethyl phthalate 6, *Indalone* 2, and *Rutgers 612* 2 parts by volume), and a check material, mineral oil, were applied to the field clothing of certain men in units A and B before they entered the bivouac areas, and to men in unit C after they entered the bivouac area. In units A and B the materials were applied by the investigators from large applicator bottles to the margins of the openings in the leggings, pants, and jackets. In unit C various methods of application were used.

The clothing of the men in unit A was treated at Camp Bullis headquarters on

the afternoon of April 8 or, in a few cases, on the morning of April 9, and the men moved into the bivouac area on the morning of April 10. The average amounts of material applied per man were as follows: Dimethyl phthalate, 1.7 fluid ounces; 6-2-2, 1.3 fluid ounces; mineral oil, 0.3 fluid ounce. The last material has no repellent effect and was applied to obtain check subjects having the same mental attitude as the treated subjects. The clothing of 32 men was treated with each repellent, and of 30 men with mineral oil.

Unit A was in bivouac areas from April 10 to 16. As the treated men were scattered through three companies, it was not practical to obtain the reports of tick attachments from each man personally. Instead they were collected by various noncommissioned officers, a method open to more inaccuracies than that followed with later groups. During the tests each man wearing treated clothing was instructed to report once each day the number of ticks (both nymphs and adults) found attached during the previous 24 hours. Reports were obtained for the first 5 days only.

The total number of attachments for a 5-day period averaged 3.7 per man for clothing treated with dimethyl phthalate, 2.4 per man for clothing treated with 6-2-2, and 7.7 per man for clothing treated with mineral oil. The maximum attachments were 10 and 16 per man for the respective repellents and 51 for the mineral oil. In all three groups some individuals reported no attachments over the 5-day period. Records of daily average tick attachments for each group indicate that the dimethyl phthalate began to lose effectiveness after 3 days, and suggest the desirability of repeating treatments at that interval.

The clothing of the men in unit B was treated on the morning of April 17 at Fort Sam Houston, and that afternoon the men entered the bivouac area at Camp Bullis. Thirty-two men had their clothing treated with 6-2-2, and 30 each with dimethyl phthalate and mineral oil. The average amounts of the materials applied per man were as follows: Dimethyl phthalate, 1.8 fluid ounces; 6-2-2, 1.4 fluid ounces; and mineral oil, 2.9 fluid ounces.

At noon every day each man reported directly to the investigators the number of ticks that had attached to him during the preceding 24 hours. This direct contact eliminated all sources of error except deliberate misstatements by the men, which were believed to be rare.

The advantage of using an inert material to treat the check groups, rather than leaving them entirely untreated, was readily apparent. The men in all three groups began the test with equal anticipation of protection, but those treated with mineral oil soon became convinced that they were using the poorest material. After 3 days each man was given a 2-ounce bottle of the material originally used on his clothing and told to apply it as it had been applied before. Those using the two repellents were eager to do this, but many of the men using mineral oil voiced the opinion that it would be a waste of time. The divergence of the opinions of the men in the various groups as the test progressed was as indicative of the value of the repellents as the actual figures reported.

The total number of attachments over the 6-day period averaged 3.9 for clothing treated with dimethyl phthalate and 3.0 for that treated with 6-2-2, as compared with 19.2 for clothing receiving mineral oil. The corresponding maximum attachments were 14, 9, and 102 per man. The minimum attachments were 0, 0, and 1, respectively.

The higher average among the group treated with mineral oil was not due to a few extreme cases. Of the 30 men in this group, 22 had 10 or more ticks attached, whereas only 2 of the 30 treated with dimethyl phthalate and none of the 32 treated with 6-2-2 had as many as 10.

Records of the daily average tick attachments in each group show that the reduction due to the repellents extended throughout the entire period and was not restricted to single days. It should be remembered that a second application was made by the men on April 20 or 21. The daily average of the group treated with dimethyl phthalate ranged from 0.2 to 1.0, of the group treated with 6-2-2 from 0.3 to 0.8, and of the group treated with mineral oil from 2.8 to 3.9.

In unit C repellent 6-2-2 was applied with a sprayer to the entire clothing of one group of 34 men, an average of 3.4 fluid ounces per man being used. In another group of 37 men each man treated

his own clothing (margins only) with 6-2-2 from the standard 2-ounce bottles, an average of 2.8 ounces per man being required. In the third group each of the 28 men treated his own clothing (margins only) with mineral oil from an applicator bottle. The men entered the bivouac area about 4 P.M., and treatments were made between 4 and 8 P.M. on April 24. The unit was located in the bivouac area during the next 5 days. No repeat treatments were made. Records were taken once each day, in the manner described for unit B.

In this unit also the group treated with mineral oil soon concluded that they had been given an inferior material.

Over the 5-day period the total number of attachments on individuals ranged from 0 to 17, with an average of 3.6, when the repellent was applied with a sprayer, and from 0 to 23, with an average of 5.1, when the applicator bottle was used. On men treating their clothing with mineral oil the number of attachments ranged from 3 to 42, with an average of 13.6. It will be noted that the men treated with a sprayer had somewhat better protection than those treated from a bottle.

Records of the average daily tick attachments in each group show that the differences between the various materials were fairly consistent for 4 days, but on the fifth day they were more nearly equal, indicating the desirability of a second treatment in midweek.

CONCLUSIONS.—Dimethyl phthalate and 6-2-2 afforded sufficient protection from ticks to justify their use for this purpose, even though complete protection was not obtained. The advantage obtained by spraying the clothing is not sufficiently great to justify the additional time required for this method of application. At least 3 fluid ounces should be used to treat one suit of field clothing, including socks and leggings. Treatments should be repeated every 3 days.

SUMMARY.—In tests at Savannah, Ga., under controlled conditions a moderately high degree of protection from ticks was obtained with *Indalone* and dimethyl phthalate. Benzyl benzoate, bisethylxanthogen, and pyrethrum were also of some value as repellents. In a field test at Camp Bullis, an adjunct of Fort Sam Houston, Tex., with troops exposed to light infestations of ticks, *Indalone*, dimethyl phthalate, and a rotenone-sulfur dust reduced tick attachments. When used in the field by troops exposed to heavy tick infestations, both dimethyl phthalate and 6-2-2 gave substantial reductions in tick attachments when applied to the margins of the clothing. Reductions were greater when the clothing was retreated after 3 days than when only one treatment in 5 days was given. Reductions were slightly greater when the entire garments were sprayed than when the margins were treated from a bottle.

Dr. John F. Alsterlund died in Bristol, Pennsylvania, on June 13, 1946. Dr. Alsterlund was a member of the research group working in the laboratories of Rohn & Haas Co., of Philadelphia. He was formerly connected with the Kentucky By-Products and Chemicals Corporation. He received his entomological training at the University of Illinois. An obituary will be published as soon as it is available.

Dr. Stanley J. Bromley writes that he has been confined to a hospital in Stamford, Connecticut, for several months. He has undergone two operations for a heart condition and states that these were successful although recovery is slow. We take occasion to express the hope of his colleagues that the recovery will be complete and that Dr. Bromley may soon get back into harness.

THOMAS J. HEADLEE

Dr. Thomas J. Headlee, an ex-president of the Association, died at his home in New Brunswick on June 14 after a period of ill health which followed his retirement a few years ago. A more extended account of his career will be published in the next issue of the JOURNAL.

SCIENTIFIC NOTES

The Mechanism of Sex Control in the Honey Bee

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In the honey bee society the role of the worker includes that of controlling the sex of all the queen's offspring. The beekeeper takes advantage of this and regulates the activities of the worker so as to bring about an increase in number of workers and, proportionately, an increase in honey production.

For over a hundred years beekeepers have known that the queen places fertilized (female) eggs in small worker cells and unfertilized (male) eggs in large drone cells, the queen acting as if she knows what kind of an egg she is going to lay and the proper type of cell to place in it. The various anatomical structures used in accomplishing this remarkable feat have been known for 40 years. The function of these structures, however, and the manner in which they cooperate to form a mechanism of sex control have always been a matter of conjecture. Within the last decade this power of sex control has been found to occur in other species of Hymenoptera. Differences in the form of the structures involved have been correlated with different methods of sex control (Flanders 1939, 1945).

It has been shown in the case of certain parasitic Hymenoptera that the female deposits fertilized or unfertilized eggs according to the attractiveness of the individuals of the host species, that is, she deposits fertilized eggs on the preferred individuals and unfertilized eggs on the unpreferred individuals. *Microplectron fuscipennis*, parasitic on the spruce sawfly, and *Tiphia popilliavora*, parasitic on the Japanese beetle, show preference by depositing fertilized eggs on large hosts and unfertilized eggs on small hosts (Brunson 1937; Ullyett 1936).

It is not surprising, therefore, that we find preferential oviposition highly developed in the queen bee. Grout (1937), while studying the influence of the brood cell on the size and variability of the worker, had difficulty in getting the queen to lay fertilized eggs in large cells when, in the same hive and at the same time, there were normal size cells available. When all the cells in each of several hives were equal in size, but differing in size between hives, the reaction of the queens appeared to be the same regardless of the cell size. In other words, the queen, if she had no chance for preferential oviposition, would deposit fertilized eggs in combs consisting of large cells. It is significant that in the comb having the largest cells there is a tendency for the drone brood to increase as the age of the comb increases. Apparently comb having a relatively low preferential or degree of attractiveness more readily loses attractiveness than normal comb.

How is the involuntary exercise of preference in oviposition correlated with the functioning of the fertilization mechanism? It is evident that the show of preference is a response to differences in degree of stimulation received when the female contacts sites suitable for the deposition of her eggs. Such a response is exhibited in man when in a state of hunger he sees, on one hand an unappetizing, dry piece of unbuttered bread, and on the other, an appetizing, thick, juicy steak; preference is indicated by the differential functioning of the salivary glands. The queen bee, apparently using the senses of touch and smell rather than of sight, when engaged in egg deposition distinguishes cell size by the degree of stimulation.

The sex controlling mechanism is in operation only while the queen is sensing the brood cell and depositing an egg. The structures involved are the antenna, the spermatheca and oviduct. Breslau (1906) and other investigators have shown that the spermatheca consists of four different parts, the sperm capsule stored with many thousands of quiescent sperms, the spermathecal gland which secretes a fluid for the activation and transport of the sperm, a sperm valve which regulates the amount of sperm discharged at a time, and a sperm duct leading from the valve to the oviduct.

The valve, when the capsule contains sperm, must remain closed except when an egg is in position to receive a sperm. It must be open, however, in order for the sperms to move in as well as for them to move out of the spermatheca. The valve therefore opens in response to the presence in the oviduct of the spermathecal fluid received at mating and of an egg with its micropyle in apposition to the orifice of the sperm duct.

In order that sperms may be discharged the instant that the valve is open, sperms must be present immediately behind the valve in a fluid which is under pressure. (The functioning of the valve as a pump is very unlikely as pointed out by Heberdey (1931).) When the spermatheca of a queen bee is placed in normal salt solution and examined at high magnification, numerous activated sperms are visible in the duct of the gland far back of both the valve and the aperture of the sperm capsule.

It is evident that as long as the glandular fluid is present and under pressure, sperms will be ejected onto every egg that passes through the oviduct regardless of the rate of oviposition.

Drone eggs would be deposited by the impregnated queen only when there is a lack of pressure behind the valve.

It is very unlikely that the valve opens in response to increased pressure from above as postulated by Heberdey. Obviously sperms could not migrate into the capsule if such was the case.

Pressure by the glandular fluid probably is derived from continued stimulation and secretion of the spermathecal gland and from the pressure of the body fluids surrounding it. This pressure may rapidly build up when the queen senses preferred brood cells and drop quickly when she senses unpreferred brood cells so that the deposition of mostly fertilized eggs in a group of worker cells alternates with the deposition of mostly unfertilized eggs in a group of drone cells.

Apparently, therefore, it is the hydraulic pressure response to cell size which enables the beekeeper to manipulate the sex ratio in the hive.—2-23-46.

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DDT as a Spot Treatment for Flies

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DDT is an excellent insecticide to combat house, stable, and other flies with similar habits (Anon. 1945, 1946; Blakeslee 1944; Gersdorff & McGovran 1944; Hunt 1944; Lindquist *et al.* 1944, 1945; Sandholzer & Lindquist 1946; Simmons & Wright 1944; Van Leeuwen 1944; Weismann 1943). A number of formulations of DDT fly sprays have been tested on the Massachusetts State College campus and about homes and dairies in the vicinity of Amherst. The proper application of the insecticide is as important for success in fly control as the insecticidal material itself. Our results with DDT showed that it is feasible under Massachusetts conditions to vary considerably from the conventional methods of application. Previously used insecticides had to strike the insects by fogging the atmosphere or by spraying extensive areas to strike the flies, while the DDT sprays can be applied where the flies normally collect for feeding and resting so that they will come into contact with the insecticide in the course of their normal activities. The flies are not repelled, in the usual sense of the term (Blakeslee, 1944), by the DDT on the treated surface and are not killed immediately, although the oil carriers may repel for a short time. In fact, the flies scatter so widely before dying that relatively few of the dead ones will be be seen. However, when the spray application was properly applied the reduction in the fly population was striking.

Our data demonstrate that DDT fly sprays need not be applied indiscriminately over extensive areas, but only where the flies are observed to collect in numbers and where the accumulation of flyspecks marks the favored resting places (Lindquist *et al.*, 1945). Such places about homes are certain window and door screens, sunny and sheltered walls about buildings, porch ceilings and entry ways and, in the house, certain windows, screens, light cords and fixtures, and similar places. When the flies are active about a building they will come into contact with the treated areas in the course of a few hours and the fly population will largely disappear. Concentrations of 5 per cent and 25 per cent DDT in the white or odorless kerosenes were used about homes. The 5 per cent strength was ample to control the flies and did not leave any objectionable deposit, which occurred with the stronger concentrations on some surfaces. However, the latter concentrations were generally more effective.

The DDT spray for eradication of flies about barns can be applied with discrimination also. Again the spray need be applied only where the flies are observed to congregate and where the accumulation of flyspecks indicates the favored resting places. Apparently all the flies in the barn will alight on such treated areas during the course of their normal activities in a few hours. The spray can be applied at any time during the day, but preferably not while milking is in progress. We have found that strong concentrations of 20 per cent to 25 per cent DDT sprays are desirable for spot treatments in barn applications. The insecticide in oil or the water-miscible products may be used with equally good results. The water-miscible sprays eliminate the fire hazard that is always present with inflammable sprays. It was wasteful of spray and especially of time and labor to apply the spray over the entire barn. This is well illustrated by the case of one dairyman milking 60 cows, who applied the spray according to our directions. A few selected spots about the barn and milk room, totaling about 80 square feet of surface, were sprayed at intervals of 3 to 10 days, beginning in late August when both house flies and stableflies were numerous in and about the buildings. Instructions were to apply the spray whenever an increase in fly population was observed. The intervals between spray applications depend largely on the number of flies that alight on the treated surface. A heavy fly population can remove the greater portion of the residual effectiveness in 3 to 5 days. This fact has been demonstrated both in the laboratory and in the field. Since it was not feasible to remove or treat the manure pile at this barn dependence for control was placed on the DDT applications. In some instances the increase in fly abundance may have been due to increased emergence produced by weather variations rather than to loss in effectiveness of the treated areas. Thus some retreatments may have been unnecessary. Four to five minutes were used in applying a 25 percent DDT in oil barn spray at each application. Ten minutes was the maximum time devoted to insecticidal applications during any week. Less than a gallon of spray was used during the season. Apparently the flies that emerged from the breeding areas about the buildings and were carried in from the field where the cows grazed were killed so rapidly after reaching the barn that the fly abundance remained at a low ebb at all times, although enormous numbers of flies must have been killed. All of the workmen about the barn were very enthusiastic over the results obtained with so little effort.

During the 1944 season the college piggery had produced a serious fly breeding situation, especially around the troughs and automatic feeders in the feed lots. The accumulation of manure about such places became packed from tramping by the pigs and served as a favored breeding medium for the flies. Several insecticides, including DDT, had failed to prevent breeding in this manure the previous season. During 1945, a system of rotation of the feeding equipment in the field at about 5-day intervals entirely prevented accumulation and packing of the manure which could serve as a breeding medium. It was necessary to move the feeders and troughs only a few feet at a time. Electric screens on the piggery windows controlled the flies fairly well during the early portion of the season, but additional control with DDT was essential in August and September. A 25 per cent DDT spray applied to selected spots about the piggery buildings kept the population low.

The frequency of applications, and areas that should be sprayed, varied considerably depending on the type of building and the abundance of flies. Frequently only one to several square feet of surface was treated about homes, while several small areas may require treatment in and around barns. In no case was it essential to spray extensive areas. This resulted in considerable saving and reduced the fire hazard from the oil carrier.

At the beginning of the season some of the workmen about the barns were reluctant to apply the sprays because of the time and labor expended in spraying during previous seasons, but the striking results in 1945 with spot treatments of DDT soon had them asking for the insecticide to apply.

Strong applications as discussed above were not recommended for applications to animals, although at least one dairyman applied one or more sprays of a 25 per cent DDT in oil to the legs of the cows without any apparent injury.—2-26-46.

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DDT for Control of the Apple Curculio

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During the season of 1945, records were made at Mitchellville on the abundance of *Tachypterellus quadrigibbus magnus* List, a subspecies of the apple curculio, in experimental plots designed, principally, to determine the comparative efficiency of DDT and lead arsenate sprays for codling moth control. The plots consisted of randomized rows of approximately 45 apple trees each, with the DDT and lead arsenate treatments replicated 6 times. Records were taken on 6 trees located at random within successive 7-tree levels along each row. The percentage of apples punctured by the insect was determined from examination at random of 50 apples on each tree without removing the fruit.

All plots received on May 2 to 11 a calyx spray of 3 pounds acid lead arsenate, 6.25 pounds of wettable sulfur, and 3 pounds of hydrated lime per 100 gallons of spray. The DDT plots received from June 1 to July 20, 5 cover sprays of 1 pound actual DDT[2] per 100 gallons followed by a spray on August 7 containing 0.75 pound; ferric dimethyldithiocarbamate[3] was used exclusively as the fungicide in these plots. The lead arsenate plots received in the same period 6 cover sprays of 4 pounds acid lead arsenate, with or without wettable sulfur or ferric dimethyldithicarbamate as fungicides, and usually with hydrated lime or zinc sulfate as safeners. A commercial petroleum oil preparation[4] (0.8 gallon per 100 gallons) was added to 3 of the lead arsenate sprays.

On May 24, the first apples punctured by curculios were found in the orchard. A slight increase in punctured apples was noted one week later, and on June 12, when the first records were taken, both new and old punctures were present. By August 10, few new punctures were found, and the old scars were rapidly becoming indistinct. Very few new punctures were observed after this date. The following table presents the results of this experiment.

Table 1.—Result of trials with DDT and lead arsenate sprays for apple curculio control.

OBSERVATION	PERCENTAGE OF PUNCTURED APPLES IN:	
	DDT Plots	Lead arsenate Plots
June 12	2.0	1.0
June 21	0.8	0.2
July 3	1.1	2.4
July 19	1.8	3.4
Aug. 10	0.7	1.1

The small degree of infestation throughout the period of observation precludes drawing definite conclusions from the experiment, yet it seems probable that DDT at 1 pound per 100 gallons is at least equal to 4 pounds of lead arsenate for controlling light infestations of this insect.—1-26-46.

[1] Journal paper No. J-1351 of the Iowa Agricultural Experiment Station, Ames, Iowa. Project No. 389.
[2] *AK-40*, manufactured by the Geigy Company, Inc.
[3] *Fermate*, E. I. duPont de Nemours and Company.
[4] *Superla*, Standard Oil Company of Indiana.

Insect Food of the Sagebrush Swift

G. F. KNOWLTON, D. R. MADDOCK, and S. L. WOOD,[1] *Utah Agricultural Experiment Station, Logan*

A study was made of the insect food, recognizable in the stomachs of 2,191 sagebrush swift lizards, *Sceloporus graciosus graciosus* (Baird and Girard), collected in Utah during the 16 years beginning in 1930. This revealed a total of 20,788 adult and 3,044 immature insects recognized at least to order; in addition 4 insect pupae (2 of Coleoptera and 2 Lepidoptera) and 138 insect eggs were found. Many of the insects were recognized to genus or species as indicated below. Because the sagebrush swift is a common and often abundant lizard, particularly in brushy areas of Utah, occurring in populations of from a dozen or so to several hundred per acre in favorable environments, this lizard should be recognized as a highly beneficial predator upon many injurious range insects. Approximately 85 per cent of Utah is range land on which insects compete with livestock for the available food plants. In addition many pest species multiply on range land, later moving into cultivated areas with ensuing damage to crops.

This work originally was undertaken in connection with a study of the feeding of this lizard upon the beet leafhopper, *Eutettix tenellus* (Baker), 297 adult and 119 nymphs of this leafhopper were recognized among food in the stomachs examined. Many other injurious species also were recognized, among them 21 adult and 24 nymphal Mormon crickets, 374 adult and 462 nymphal grasshoppers, 185 termites, 62 adult and 27 nymphal *Lygus* sp. bugs, 968 adult and 541 nymphal false chinch bugs, 112 adult and 16 nymphal Pentatomidae, 1273 Aphididae, 35 adult and 3 larval Elateridae, flea beetles, weevils, 188 diamond back moth alrvae, cutworms, and miscellaneous pests of lesser importance.

Recognizable insect food of the lizard consisted of the following:

Thysanura 6[2]
Collembola 24[2]
Orthoptera 906
  Tettigoniidae 3[3]
    Anabrus simplex Hald. 45 (24 nymphs)
  Gryllidae 19
  Locustidae 741 (447 nymphs)—*Aulocara elliotti* Thomas 9 (8 nymphs), *Conozoa* sp. 1, *Hippiscus corallipes* Hald. 1, *Melanoplus* sp. 15 (3 nymphs), *M. canonicus* Scud. 1, *M. femur-rubrum* (De G.) 38, *M. mexicanus* Riley 26 (4 nymphs), *Mermeria* sp. 1, *Trimerotropis* sp. 3.
  Mantidae 3 (1 nymph)
Isoptera 185
Neuroptera 54
  Raphidiidae 1
  Chrysopidae 14 (13 nymphs)
  Myrmeleonidae 20 (5 nymphs)
Odonata 7
  Dragon flies 3
  Damsel flies 2
Corrodentia 2
Thysanoptera 7[2]
Hemiptera 3140
  Miridae 60—*Adelphocoris superbus* (Uhler) 5 (4 nymphs), *Lygus elisus* Van D. 18 (1 nymph), *L. hesperus* Kngt. 19 (5 nymphs), *Lygus* sp. 52 (21 nymphs)
  Nabidae 7 (2 nymphs)—*Nabis alternatus* Parsh 7, *Nabis ferus* (Linn.) 4
  Reduviidae 25—*Reduvius personatus* (L.) 1
  Phymatidae 2
  Tingidae 85 (41 nymphs)
  Piesmidae 21
  Lygaeidae 79—*Emblethis vicarius* Horv. 2, *Geocoris* sp. 85 (6 nymphs), *G. atricolor* Montd. 7, *G. bullatus* (Say) 2, *G. decoratus* Uhl. 101 (2 nymphs), *Lygaeus* sp. 14, *Lygaeus kalmii* Stål, 12, *L. reclivatus* Say 3, *Nysius ericae* (Schilling) 1509 (541 nymphs)
  Corizidae 5—*Corizus* sp. 17 (5 nymphs), *C. hyalinus* (Fabr.) 1, *C. lateralis* (Say) 1
  Pentatomidae 79 (14 nymphs)—*Brochymena quadripustulata* (Fabr.: 1, *Chlorochroa congrua* Uhl. 1, *C. uhleri* Stål. 1, *C. ligata* (Say) 1. *C. sayi* Stål 6, *Thyanta* sp. 2, *T. custator* (Fabr.) 16 (2 nymphs), *T. rugulosa* (Say) 21
  Scutelleridae 5—*Eurygaster alternatus* (Say) 1
Homoptera 2228
  Cicadidae 5 (1 nymph)
  Cercopidae 17
  Membracidae 12—*Leioscyta ferruginipennis* (Godg.) 4
  Cicadellidae 346 (36 nymphs)—*Acerotagallia* sp. 29, *A. sanguinolenta* Prov. 11, *Eutettix tenellus* (Bkr.) 416 (119 nymphs), *Phlepsius ovatus* Van D. 5, *P. spatulatus* Van D. 2, *Thamnotettix montanus* Van D. 1, *T. venditerius* Ball 1, *Xerophloea viridis* (Fabr.) 2
  Fulgoridae 12—*Scolops angustatus* Uhl. 1, *S. sulcipes* (Say) 3
  Chermidae 15
  Aphididae 1, 196[2]—*Aphis bonnevillensis* Knlt. 1, *A. medicaginis* Koch 2, *Capitophorous oestlundi*, Knlt. 1, *Clavigerus smithiae* (Mon.) 2, *Epameibaphis utahensis* K.-S. 3, *Macrosiphum* sp. 4, *M. ambrosiae* (Thomas) 3, *M. coweni* Hunter 13, *M. filifoliae* G.-P. 3, *M. ludovicianae* (Oest.) 5, *M. pisi* Kalt, 39, *Pemphigus* sp. 1
  Coccidae 41[2]
Coleoptera 2421
  Cicindelidae 6 (1 larva)
  Carabidae 273 (14 larvae)
  Silphidae 7—*Silpha lapponica* Hbst. 4, *S. opaca* L. 1
  Staphylinidae 41
  Histeridae 12
  Malachiidae 8—*Collops bipunctatus* Say 1
  Cleridae 1
  Rhipiphoridae 2
  Meloidae 4
  Anthicidae 1
  Elateridae 38 (3 larvae)
  Buprestidae 10
  Dermestidae 16 (10 larvae)
  Cucujidae 3
  Coccinellidae 72 (30 larvae)—*Coccinella perplexa* Muls. 1, *C. quinquenotata* Kby. 4, *C. transversoguttata* Fall. 3, *Exochamus marginipennis* Lec. 1, *Hippodamia* sp. 6, *H. americana* Cr. 6, *H. convergens* Guer. 111 (22 larvae), *H. lunatomaculata* Mots. 10, *H. parentheses* (Say) 5, *H. tredecim-punctata* (L.) 1, *Scymnus marginicollis* Mann. 1
  Tenebrionidae 61 (6 larvae)
  Scarabaeidae 109 (2 larvae),—*Aphodius distinctus* (Mull.) 16, *A. granarius* (L.) 13

[1] Research professor, graduate and undergraduate student, respectively.
[2] Total includes adult and immature forms.
[3] The total for family does not include genera and species listed beneath it.

Lucanidae 1
Cerambycidae 5
Chrysomelidae 239 (14 larvae)—Flea beetles 99, *Disonycha* sp. 14, *Monoxia debilis* Lec. 1, *Pachybrachys* sp. 2, *Systena taeniata* (Say) 5, *Trirhabda nitidicollis* Lec. 24, *Zygogramma exclamations* (Fab.) 1
Curculionidae 122—*Phytonomus posticus* (Gyll.) 4 (larvae)
Scolytidae 3
Mecoptera 1 larva
Trichoptera 2
Lepidoptera 1391 (1044 larvae and 2 pupae)
Plutellidae,—*Plutella maculipennis* (Curt.) 118 larvae
Sphingidae 2
Geometridae 3 (2 larvae)
Phalaenidae 1
Army cutworms 5 larvae, cutworms 14 larvae, variegated cutworms 9 larvae
Diptera 1191
Tipulidae 18
Chironomidae 602
Culicidae 3
Tabanidae 6-*Chrysops* sp. 1 larva, *Tabanus* sp. 2
Stratiomyidae 3
Bombyliidae 2
Therevidae 1
Asilidae 14
Pipunculidae 4
Syrphidae 2—*Mesogramma marginata* Say 1
Cordyluridae 3
Chloropidae 5—*Chloropisca glabra* Meig. 29
Drosopilidae 1
Anthomyiidae 2
Calliphoridae 12
Sarcophagidae 6—*Sarcophaga kelleyi* Aldrich 1
Tachinidae 2—*Fabriciella* sp. 5, *F. spinosa* Toth. 1
Muscidae 14—*Musca domestica* L. 1
Hymenoptera 12,267
Tenthredinidae 1
Braconidae 3
Ichneumonidae 21—*Ephialtes pedalis* (Cress.) 1
Chalcididae 29
Pompilidae 1
Chrysididae 11
Mutilidae 2
Formicidae 11,462
Vespidae 16
Sphecidae 6
Andrenidae 31
Megachilidae 1
Bombidae 1
Apidae 43—*Apis mellifica* L. 2
Misc. insect eggs 138
Spiders 315
Mites 235
Ticks 24
Pseudocorpions 5
Scorpions 5
Chilopoda 3
Symphyla 1
Roundworms 122
Snail 1
Lizard of some species 1
Seeds 2
Plant fragments and sand were present in many of the stomachs

Grand total, 20,788 adults and 3044 immature insects in the stomachs of 2191 individuals of *Sceloporus g. graciosus* (B.-G.).—1-16-48.

Normal Offspring Produced by Moribund Aphids Treated with DDT

FLOYD F. SMITH, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

The mode of killing action of DDT is the object of consideration by many entomologists and of active research by a few. According to Yeager & Munson (1945)[1] it may penetrate the body wall of the housefly in various places, and in roaches it may cause twitches and tremors by acting somewhere along the nerves outside of the central nervous system. Although DDT might affect other tissues as well, it may be considered to be a nerve poison to the extent of producing contractions, twitches, and tremors. On aphids the usual symptoms as observed by the writer are tremors, followed by uncoordinated movements of the appendages, inability to feed, paralysis, body shriveling, and death.

Beginning in December 1944, small-scale laboratory experiments were conducted to compare the toxicity to *Myzus persicae* (Sulz.) of DDT in aerosols, emulsions, solutions, suspensions, and dusts. The infested foliage was treated and then arranged so that affected aphids dropped into enamel pans ringed at the margin with tanglefoot to prevent their escape. When examined 1, 2, and 3 days after treatment, the affected aphids were dead or were in the various stages preceding it. Among the moribund adults were frequently found normal-appearing aphids in the first instar and apparently unfed. Further observations disclosed that affected adults, with bodies shriveled for lack of food, were giving birth to these offspring for as long as three days after treatment. The aphids dropped from the foliage at about the same rate after all treatments. but death was most rapid and fewest young were produced after treatment with the aerosols or emulsions. Death was increasingly slower and more young were produced by moribund adults after treatment with solutions, spray suspensions, and dusts in the order named. The normalcy of the offspring from moribund adults was confirmed by transferring them by brush to untreated host plants, where they established colonies.

In recent field experiments both *Myzus persicae* and *Macrosiphum solanifolii* (Ashm.) remained moribund on the soil beneath potato foliage for two days after treatment, and collected individuals gave birth to living young before dying.

The symptoms observed in the treated aphids are in agreement with other evidence that at least a part of the action of DDT is that of a nerve poison. If it gets into or passes through the ovarian walls. it must do so without causing apparent symptoms in the unborn young. If the DDT affects the nerves in the reproductive organs, it does so without preventing the extrusion of the offspring.

These observations may also explain some of the differences in the aphicidal effectiveness of DDT in aerosols, emulsions, solutions, suspensions, and dusts in the field. The importance of the residual effect of the DDT treatment in the control of these newborn young is evident.—1-16-46.

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[1] The writer appreciated the suggestions and criticisms of this paper by these authors.

Insect Food of the Mountain Bluebird

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A study has been made to determine the kinds of insects eaten by the mountain bluebird, *Sialia currucoides* (Bechs.), in rangeland areas and cultivated localities of Utah. This report is based on insects recognized at least to order, contained in 194 mountain bluebird stomachs collected in Utah during 1934 through 1945.

As shown in table 1, 17 stomachs were collected from April through June, 66 during July and August, and 111 through September and October. The larger number taken during the fall was collected to determine the extent to which this bird fed upon beet leafhoppers in desert breeding areas of this insect. Only 23 adult and 4 nymphal beet leafhoppers, *Eutettix tenellus* (Baker), were recognized among insects contained in these bluebird stomachs. The majority of the insects recognized were injurious or probably injurious; a few were beneficial parasites or predators.

Insects recognized at least to family would include the following:

ORTHOPTERA
- Tettigoniidae 64
- Locustidae 112—including *Dissosteira carolina* (L.) 1, *Melanoplus femurrubrum* (De G.) 1, *M. mexicanus* Riley 1, *Camnula pellucida* (Scud.) 1, *Trimeritropus* 3.

NEUROPTERA
- Chrysopid larva 1

HEMIPTERA
- Scutelleridae 1
- Pentatomidae 25 (1 nymph)—including *Brochymena* 4, *B. 4-pustulata* (Fabr.) 3, *Chlorochroa sayi* Stål 1, *C. uhleri* Stål 1, *Euschistus inflatus* Van D. 1, *Thyanta custator* (Fabr.) 2.
- Corizidae—*Corizus hyalinus* (Fabr.) 1, *C. punctiventris* (Dell.) 2, *C. viridicatus* Uhl. 1.
- Coreidae—*Chelinidea vittiger* Uhl. 5
- Lygaeidae 91 (11 nymphs)—*Geocoris* 4, *Nysius ericae* (Schl.) 75 (4 nymphs), *Lygaeus kalmii* Stål 11 (7 nymphs), *L. reclivatus* Say 1.
- Reduviidae 1
- Miridae 18 (7 nymphs)—*Lygus elisus* Van D. 5, *L. hesperus* Knt. 3.
- Corixidae 1
- Notonectidae 1

HOMOPTERA
- Membracidae 3,—*Campylenchia latipes* (Say) 1
- Cicadellidae 55 (14 nymphs)—*Eutettix tenellus* (Baker) 27 (4 nymphs), *Aceratagallia sanguinolenta* Prov. 1, *Helochara communis* Fitch 2, *Xerophloea viridis* (Fabr.) 3
- Fulgoridae 1
- Chermidae 3—*Trioza* 2, *Paratrioza cockerelli* (Sulc) 1
- Aphididae 67—*Macrosiphum coweni* (Hunter) 4, *M. granarium* (Kby.) 4, *M. pisi* (Kalt.) 22

COLEOPTERA
- Cicindelidae 1
- Carabidae 52 (1 larva)
- Silphidae 2
- Staphylinidae 5
- Lycidae 1
- Malachiidae 5—*Collops bipunctatus* Say 4
- Meloidae 17—*Epicauta maculata* (Say) 16, *E. oregona* Horn 1
- Elateridae 6—*Athous nigripilis* Mots. 1
- Buprestidae 4
- Dermestidae 2
- Nitidulidae 2
- Coccinellidae 10
- Tenebrionidae 12
- Bostrichidae 1
- Scarabaeidae 193—*Aphodius distinctus* (Mul.) 171, *A. granarius* (L.) 3
- Cerambycidae 25—*Crossidius pulchellus* Lec. 16
- Chrysomelidae 36—*Lina scripta* (Fabr.) 1, *Monoxia debilis* Lec. 1, *Trirhabda nitidicollis* Lec. 1, *Zygogramma exclamations* (Fabr.) 3
- Curculionidae 60 (9 larvae)—*Phytonomus posticus* (Gyll.) 16 (6 larvae.), *Hypera punctata* (Fabr.) 2, *Sitona hispidulus* (Fabr.) 1
- Scolytidae 5—*Dendroctonus* 2

LEPIDOPTERA 190 (169 larvae, besides 7 eggs)
- Pyralidae 7—*Loxostege sticticalis* (L.) 7 (larvae)
- Sphingidae 2—*Celerio lineata* (Fabr.) 2 (larvae)

DIPTERA 72 (30 larvae)
- Tipulidae 5
- Chironomidae 6
- Bibionidae 1
- Trypetidae 1
- Calliphoridae 4
- Muscidae 3

HYMENOPTERA
- Ichneumonidae 1
- Chalcididae 2
- Chrysididae 1
- Mutillidae 1
- Formicidae 573
- Vespidae 4
- Andrenidae 14
- Megachilidae 1

Spiders 18

Seeds 58 (3 kernels of wheat)

Berry and fruit seeds 10

In addition, several hundred mandibles of Orthoptera and fewer of Coleoptera, etc. were present, sometimes 10 to 17 occurring in a single stomach.—1-16-48.

Table 1.—Summary of insects recognizable in 194 mountain bluebird stomachs, collected in Utah from 1934 through 1945.

INSECT ORDER	17 STOMACHS April–June	66 STOMACHS July–August	111 STOMACHS Sept.–Oct.	TOTAL
Thysanura	0	2	1	3
Orthoptera	10	87	130	227
Isoptera	0	3	3	6
Neuroptera	1	1	6	8
Odonata	0	1	2	3
Corrodentia	0	0	1	1
Hemiptera	30	92	131	253
Homoptera	32	54	37	123
Coleoptera	130	267	445	842
Lepidoptera	20	86	84	190
Diptera	7	57	8	72
Hymenoptera	132	201	413	746
TOTAL	362	851	1261	2474

[1] Research professor of Zoology and Entomology and former graduate assistant, respectively.

Desiccators as Constant Humidity Chambers

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"For the purpose of maintaining a constant humidity in a closed chamber, sulfuric acid solutions have no real competitor under ordinary conditions, since it is merely necessary to place within the chamber some acid of the proper strength with an amount of surface exposed in general somewhat larger than that of any other moist or hygroscopic material present" (Wilson, 1921).

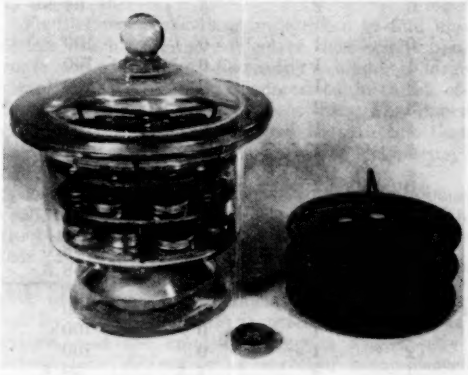

FIG. 1.—Photograph of a desiccator, tray, and set of rearing cages, used in temperature-humidity experiments.

Figure 1 shows a desiccator being used as a humidity chamber in life history studies of the rusty grain beetle, *Laemophloeus ferrugineus* (Steph.). During the last 3 years, this type of chamber has proven very satisfactory for temperature-humidity studies on the above insect at the University of Western Ontario and the University of Wisconsin, and should prove of equal value for similar studies on other species of animals. Any desired humidity can be obtained within the desiccator by introducing into its basal part sulfuric acid and distilled water in the proper proportions. The densities of the sulfuric acid solutions needed to give various humidities can be determined from data given in Wilson's paper. Inside the desiccator is a three-tiered metal tray which holds thirty-six individual rearing cages made from one-quarter ounce metal salve boxes. With several similarly equipped desiccators the effect of different humidities upon the incubation period of eggs, larval development, percentage survival, etc. can be studied simultaneously in the same temperature chamber and hence at the same temperature.

The individual rearing cage is made by cutting a circular opening through the lid of the salve box with a hollow metal punch. The aperture is then covered with a small piece of silk bolting cloth glued in place with *Duco* household cement. Rearing cages of this type are especially well suited for work under the binocular microscope because they are shallow and of sufficient diameter to permit plenty of light to enter and to allow freedom of manipulation of dissecting needles or other instruments while making observations.

The shelves of the tray can be easily constructed from lids of old tobacco cans or other metal containers; or they can be made directly from new sheet-metal. They are held in place by three lengths of stiff wire which are extended below the bottom shelf to form short legs which hold the tray clear of the inside ledge of the desiccator. The wires are also extended beyond the upper shelf, where they are soldered together to form a handle for removing the tray from the desiccator (Fig. 1). The diameter of the tray should be less than that of the interior of the desiccator, and holes should be made through all three shelves. These precautions insure free circulation of air throughout the chamber.—2-2-46.

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Materials as Effective as Benzyl Benzoate for Impregnating Clothing Against Chiggers[1, 2]

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Scrub typhus (tsutsugamushi disease) is transmitted to man by some species of mites in certain areas of the South Pacific and the China-Burma-India theaters of war. Because of the incidence of this disease among military personnel, the United States of America Typhus Commission early in 1944 requested the Orlando, Fla., laboratory of the Bureau of Entomology and Plant Quarantine to reopen its investigations in an effort to find more effective control materials than dimethyl phthalate. Particular emphasis was to be placed on finding materials which would be more effective than dimethyl phthalate when exposed to rains, wading, and ordinary field laundry. Previous work on materials to control mites at Orlando had been discontinued in 1942.

Madden *et al.* (1944) found that dimethyl phthalate was an effective treatment for preventing attachments of chiggers, when it was applied from a small-mouthed bottle in a half-inch band around all openings of the outer clothing, but that this material was partially removed by exposure to water or mild laundering. Australian army workers confirmed these findings, but found that a related compound, dibutyl phthalate, was as effective as dimethyl phthalate and was more resistant to leaching and laundering. Dibutyl phthalate was subsequently adopted for use by the Australian armed forces in the field.

In 1944 F. A. Morton (unpublished manuscript) developed methods of impregnating clothing with dimethyl phthalate combined with miscible emulsifiers. Such materials, however, were not yet available in military theaters. After extensive tests in

[1] *Eutrombicula* and related genera.

[2] This work was conducted under a transfer of funds, recommended by the Committee on Medical Research, from the Office of Scientific Research and Development to the Bureau of Entomology and Plant Quarantine.

[3] The writers wish to acknowledge the suggestions made by E. F. Knipling, in charge of the Orlando, Fla., laboratory, and the assistance of H. A. Jones, chemist, in the preparation of materials used for testing.

Table 1.—Results of field tests of clothing impregnated with various mite-killing materials. Dosage 2 grams per square foot.

Chemical	Washes	Tests	Average Attachments	Reduction Compared to Check[1]
	Number	*Number*	*Number*	*Per Cent*
Benzil	0	1	0	100
	1	1	0	100
	2	1	0	100
	3	2	1.5	99.7
	4	2	0	100
	5	2	0	100
	6	2	5	96.8
Benzoic acid, phenyl ester (phenyl benzoate)	0	1	0	100
	1	1	0	100
	2	1	0	100
	3	2	0.5	99.8
	4	1	0	100
	5	1	222	0
Benzoic acid, 3,5-dimethylphenyl ester	0	1	0	100
	1	2	2.5	94.9
	2	1	0	100
	3	1	2.5	98.0
	4	2	50.5	58.5
1,2,5,6-Tetrahydro-*o*-methyl benzoic acid, 1,2,5,6-tetrahydro-*o*-methylbenzyl ester	0	1	0	100
	1	1	0	100
	2	1	0	100
	1	2	1.5	99.6
	4	1	44	26.7
Phenaxathin (phenothioxin)	0	1	0	100
	1	1	0	100
	2	1	0	100
	3	1	0	100
	4	1	201	0
p-Methoxydiphenyl	0	1	0	100
	1	2	0	100
	2	1	0	100
	3	2	2.5	98
	4	1	58	0
Benzoic acid, alpha-methylbenzyl ester	0	1	0	100
	1	2	0	100
	2	1	0	100
	3	2	1.5	98.8
	4	1	11	0
Benzoic acid, phenylethyl ester	0	1	0	100
	1	1	0	100
	2	1	0	100
	3	1	8	96.5
Benzoic acid, 2-chlorophenyl ester	0	1	0	100
	1	1	0	100
	2	1	0	100
	3	1	35	84.5
Benzoic acid, benzyl ester (benzyl benzoate)	0	5	1.8	99.2
	1	5	0	100
	2	4	0.75	99.7
	3	7	34	81.6
Check (untreated)	—	27	169	—

[1] Figures given are based on concurrently tested check uniform, and were obtained by the formula:

$$100 - \frac{\text{Number of attachments on treated uniform} \times 100}{\text{Number of attachments on check uniform}}.$$

New Guinea, the Typhus Commission recommended that entire uniforms be dipped in an emulsion containing 5 per cent of dimethyl phthalate and 2 per cent of G. I. soap (War Dept. 1944).

Snyder & Morton (unpublished manuscript) showed that, under field conditions in Florida, benzyl benzoate when freshly applied was as effective as dimethyl phthalate and dibutyl phthalate in preventing chigger attachments, and was more effective than either of these materials when the treated clothing was washed by several methods. Benzyl benzoate afforded complete protection of clothing even after two washings and a high degree of protection after three washings of any type used in these tests.

Further work was then undertaken to find materials which were more effective then benzyl benzoate and which might be readily available in large quantities. Those that appeared to be most effective were given practical field tests. This paper gives the results obtained with 10 materials that were found to be equal to or better than benzyl benzoate in these field tests.

Two-piece fatigue uniforms of cotton herringbone twill, and also wool socks, were impregnated with the test materials at the rate of 2 grams per square foot (about 8 per cent by weight of cloth). The clothing was dipped into a solution or water emulsion of the various chemicals, and then wrung out by hand. The solvent used was acetone or xylene, and the emulsifying agent was a polyoxyethylene derivative of sorbitan mono-oleate[1] (0.5 per cent). The materials were impregnated and tested in groups of four—one benzyl benzoate control and three test materials.

Research subjects wore the treated uniforms and socks for 1 hour in an area heavily infested with chiggers. A subject in an untreated uniform spent the same length of time in the same area to serve as a check. During the test period the subjects either sat or lay on the ground so that as many chiggers as possible could crawl onto them. After this exposure the uniforms were worn for an additional 2 to 3 hours and then removed. A count was made of the actual number of chiggers attached to the subjects.

The uniforms and socks were washed and tested until they no longer afforded a high percentage of protection. A wash consisted of laundering a single garment for 10 minutes in a household electric washing machine with 20 gallons of water at 120° F. and 0.76 per cent of soap. The garment was put through a hand wringer and machine-rinsed twice for 5 minutes each time in 20 gallons of cool tap water. After each rinse the garment was put through the hand wringer.

The results of these tests are presented in table 1. Benzil afforded almost complete protection for three more washings, and phenyl benzoate for two more washings, than benzyl benzoate which was tested concurrently. All the remaining materials were as effective as benzyl benzoate, and gave a higher percentage of protection after the third wash. Benzil is already in commercial production, and large quantities have been used by the Chemical Warfare Service.

Sufficient tests have not yet been completed to permit definite recommendation of any of the materials mentioned in this paper other than benzyl benzoate.—3-4-46.

[1] *Tween 80.*

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Distribution Records for Mosquitoes of the Southeastern States in 1945

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The extensive mosquito survey program carried on by Army installations in the Fourth Service Command since 1942 was continued through 1945, further adding to the previously known distribution of mosquito species in the southeastern United States. New distribution records from these surveys in the years 1942 through 1944 were presented by King *et al.* (1943), Middlekauff & Carpenter (1944) and Carpenter *et al.* (1945). Additional new records from the 1945 surveys are here presented, comprising six new state records and 106 additional locality records from the 400,833 specific identifications of mosquitoes collected at 127 Army installations during the year. The area represented in these surveys comprises the following states: Alabama, Florida, Georgia, Mississippi, North Carolina, South Carolina and Tennessee.

Locality records listed are those which extend the geographical range or which represent new localities for the occurrence of species within their known range. Special emphasis has been placed on species which are relatively rare or seldom collected.

Additional records are given for the inland occurrence of salt or brackish water *Aëdes* and *Anopheles*. These inland records for *Anopheles bradleyi* indicate a comparatively long flight range for the species. Identification of these specimens of *A. bradleyi* was based on the presence of pale scales on a portion or all of the stem of wing vein 5, a character pointed out by King and further confirmed in this laboratory as a dependable character by rearing and associating adults with the larval skins.

Anopheles georgianus, described as a variety of *A. crucians* from southern Georgia in 1939, is at present distinguishable only as larvae. The records here given for these larvae include localities in coastal regions where *A. bradleyi* is commonly collected.

Records of *Aëdes atlanticus* and *A. tormentor* are of males and larvae only, as no characters are as yet known for separating females of these species. During the year, 7996 females were recorded as *A. atlanticus-tormentor* and, compared with a total of 2411 *atlanticus*, only 15 *tormentor* males and larvae were identified, indicating the relative proportions of the two species. The comparatively rare *A. tormentor* records show a distribution for the species over most of the known range for *A. atlanticus*.

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[3] It is desired to express appreciation to Miss Elaine Smith, SP-5, Miss Winona Gilstrap, SP-5, Miss Lenora Peeples, SP-5, Sergeant William D. Sudia and others in this laboratory and in the field whose efforts have made the presentation of these records possible.

Table 1.—New distribution records for the mosquitoes of the southeastern states in 1945, arranged according to species, locality, date of collection, number and sex. The collections are listed according to type as indicated by the following symbols: (T) light trap (New Jersey type); (S) resting station; (B) biting; and (L) larval.

Species and Locality	Inclusive Dates of Collections	Specimens and Collection Methods
Aëdes atlanticus D. & K.		
Como POW Camp, Como, Miss.	July 11	1♂* (T)
Camp Butner, Durham, N. C.	July 12	2♂♂* (T)
	July 27–31	2♂♂* (T)
	Aug. 4	1♂* (T)
	Aug. 29	1♂* (T)
	Sept. 20	6 (L)
Aëdes cinereus Meig.		
AAF Tuskegee, Ala.†	May 10	1 (L)
Camp Stewart, Hinesville, Ga.	Oct. 6	1♂* (T)
Camp Wheeler, Macon, Ga.	June 6	1♀ (B)
Cochran Field, Macon, Ga.	May 28	1♂* (T)
	June 4–6	2♂♂* (T)
	Sept. 3	1♂* (T)
Headquarters 2nd Army, Memphis, Tenn.	April 23	1♂* (T)
Aëdes dorsalis (Meig.)		
POW Camp, Como, Miss.†	July 9	1♀ (T)
Aëdes dupreei (Coq.)		
POW Camp, Como, Miss.	June 26	1♂ (T)
	Aug. 23	1♂ (T)
Fort Bragg, Fayetteville, N. C.	Sept. 26	1♀ (S)
Camp Butner, Durham, N. C.	Oct. 13	1♀ (S)
Laurinburg-Maxton Field, Maxton, N. C.	Sept. 3–28	23♂♂, 23♀♀ (T)
	Oct. 1–12	9♀♀ (T)
Camp Mackall, Hoffman, N. C.	Sept. 24–27	5 (L)
	Oct. 19	2♀ (S)
Seymour-Johnson Field, Goldsboro, N. C.	Aug. 31	1♂ (T)
	Oct. 10	1♀ (S)
Kennedy Genl. Hosp., Memphis, Tenn.	July 4	1♂ (T)
AAB, Smyrna, Tenn.	July 20	1♂ (T)
Aëdes fulvus pallens Ross		
Camp Blanding, Starke, Fla.	July 11	1♀ (T)
Drew Field, Tampa, Fla.	July 9	1♀ (T)
AAF, Marianna, Fla.	Aug. 13	1♀ (T)
Tyndall Field, Panama City, Fla.	Aug. 1	1♂ (T)
Camp Stewart, Hinesville, Ga.	Aug. 11	1♀ (T)
Fort Benning, Columbus, Ga.	May 7	2 (L)
Camp Van Dorn, Centerville, Miss.	July 2	1♀ (S)
Bluethenthal Field, Wilmington, N. C.	July 20	1♀ (T)
Laurinburg-Maxton Field, Maxton, N. C.	July 16	1♀ (T)
	Aug. 29	20 (L)
AAF, Myrtle Beach, S. C.	July 7–Aug. 3	1♂, 64♀♀ (T)
	July 7–9	9♂♂, 21♀♀ (S)
	July 24	1 (L)
	Sept. 11	8 (L)
	Sept. 21	1♀ (T)
	Oct. 19–Nov. 1	2♀♀ (T)
Aëdes infirmatus D. & K.		
Huntsville Arsenal, Huntsville, Ala.	Sept. 5	1♀ (S)
Oliver Genl. Hosp., Augusta, Ga.	Nov. 3	1♀ (S)
AAF, Greenwood, Miss.	July 11	1♂ (T)
Camp Davis, Wilmington, N. C.	July 23	1♀ (T)
Laurinburg-Maxton Field, Maxton, N. C.	Sept. 10	1♀ (T)
	Oct. 1	5♂♂, 1♀ (T)
Kennedy Genl. Hosp., Memphis, Tenn.†	June 28	1♂ (T)
Aëdes sollicitans (Walk.)		
AAF, Marianna, Fla.	Aug. 22	1♀ (T)
Chatham Field, Savannah, Ga.	Aug. 29	1♀ (S)
Cochran Field, Macon, Ga.	July 10	1♀ (T)
Oliver Genl. Hosp., Augusta, Ga.	July 23	1♂, 1♀ (T)

Table 1.—(*continued*)

SPECIES AND LOCALITY	INCLUSIVE DATES OF COLLECTIONS	SPECIMENS AND COLLECTION METHODS
POW Camp, Clinton, Miss.	Sept. 7	1♀ (T)
	July 13–18	4♀♀ (T)
AAB, Jackson, Miss.	July 12	1♀ (T)
	July 25–27	2♀♀ (T)
	Aug. 9–10	2♀♀ (T)
Camp Butner, Durham, N. C.	May 28–30	2♀♀ (T)
	July 23	1♀ (T)
Aëdes sticticus (Meig.)		
Welch Convalescent Hosp. Daytona Beach, Fla.	July 21	1♀ (S)
AAB, Columbia, S.C.	April 12	2♂♂ (T)
	May 20–June 3	4♂♂*, 1♀ (T)
Fort Jackson, Columbia, S. C.	April 8–16	2♂♂* (T)
	May 25–June 2	1♂*, 3♀♀ (S)
Stark Genl. Hosp., Charleston, S. C.	Mar. 27	1♂ (T)
AAF, Dyersburg, Tenn.	June 26	1♂* (S)
AAF, Smyrna, Tenn.	June 11–13	2♀♀ (T)
	July 2	1♂* (T)
Seymour Johnson Field, Goldsboro, N.C.	April 10	1♀ (S)
	April 16	1♀ (S)
Aëdes taeniorhynchus (Wied.)		
Maxwell Field, Montgomery, Ala.	July 30	1♀ (T)
AAF, Lakeland, Fla.	July 4	20♀♀ (S)
	July 12	2♀♀ (S)
Camp Butner, Durham, N. C.	Sept. 21	1♀ (S)
AAF, Florence, S. C.	July 3	1♀ (S)
	July 16	1♀ (T)
Aëdes thibaulti D. & K.		
Internment Camp, Aliceville, Ala.	April 9	1♀ (S)
	April 18	1♀ (S)
Gunter Field, Montgomery, Ala.	April 12	1♀ (S)
Camp Wheeler, Macon, Ga.	May 29	5♀♀ (S)
	May 29	1♀ (B)
	June 6	1♀ (T)
	June 18–28	4♀♀ (B)
	Aug. 21	1♀ (B)
AAF, Columbus, Miss.	April 3–May 5	7♂♂, 8♀♀ (S)
Laurinburg-Maxton Field, Maxton, N. C.	May 11	2♀♀ (B)
Aëdes tormentor D. & K.		
Gunter Field, Montgomery, Ala.	May 21	1♂* (T)
AAF, Marianna, Fla.	May 11	1♂* (T)
	June 25	1♂* (T)
	Aug. 29	1♂* (T)
Hunter Field, Savannah, Ga.	Sept. 5	3 (L)
POW Camp, Clinton, Miss.	Aug. 10	1♂* (T)
AAB, Jackson, Miss.	July 15	1♂* (T)
Laurinburg-Maxton Field, Maxton, N. C.	Oct. 1	1♂* (T)
AAF, Myrtle Beach, S. C.	May 30–June 1	2♂♂* (T)
	July 11	1♂* (T)
	July 16	1 (L)
	Aug. 29	1♂* (T)
Anopheles atropos D. & K.		
AAF, Avon Park, Fla.	Aug. 3	1♀ (T)
Anopheles bradleyi King		
AAF, Bushnell, Fla.	Mar. 7	1♂ (S)
Chatham Field, Savannah, Ga.	Feb. 21	1♀ (S)
	April 18	1♀ (T)
Camp Gordon, Augusta, Ga.	Nov. 9	1♀ (S)
Camp Stewart, Hinesville, Ga.	Feb. 13–15	2♀♀ (T)
ASF Depot, Savannah, Ga.	Aug. 22	1♀ (T)
	Aug. 27	2♀♀ (T)
Fort Bragg, Fayetteville, N. C.	June 2	1♀ (S)
Camp Butner, Durham, N. C.	July 14	1♀ (S)
Laurinburg-Maxton Field, Maxton, N. C.	Mar. 27	1♀ (T)
	Oct. 15–19	2♀♀ (T)
Fort Jackson, Columbia, S. C.	May 16	1♀ (T)

Table 1.—(*continued*)

SPECIES AND LOCALITY	INCLUSIVE DATES OF COLLECTIONS	SPECIMENS AND COLLECTION METHODS
Anopheles georgianus King		
Brookley Field, Mobile, Ala.	Mar. 27–28	8 (L)
Gunter Field, Montgomery, Ala.	April 5	2 (L)
Tundall Field, Panama City, Fla.	Feb. 7	1 (L)
ASF Depot, Savannah, Ga.	April 14	6 (L)
AAB, Gulfport, Miss.	Jan. 13	20 (L)
	Feb. 7–8	19 (L)
	Mar. 7–13	4 (L)
Keesler Field, Biloxi, Miss.	Mar. 22	1 (L)
AAB, Greenville, S. C.	April 11	1 (L)
AAF, Orangeburg, S. C.	April 13	2 (L)
AAF, Myrtle Beach, S. C.	Aug. 7	1 (L)
Anopheles walkeri Theobald		
Fort Benning, Columbus, Ga.	Sept. 26	1♀ (T)
ASF Depot, Savannah, Ga.	April 4	1♀ (T)
	July 4	1♀ (T)
	Aug. 6	2♀♀ (T)
AAB, Jackson, Miss.	June 10	1♀ (T)
Keesler Field, Biloxi, Miss.	Oct. 22	1♀ (T)
Culex pilosus (D. & K.)		
POW Camp, Como, Miss.	Sept. 20, 1944	1♂* (S)
Mansonia indubitans Dyar & Shannon		
Drew Field, Tampa, Fla.	July 6	2♀♀ (T)
	Aug. 3–10	2♀♀ (T)
	Sept. 3	1♀ (T)
Hendricks Field, Sebring, Fla.	Aug. 1	2♀♀ (T)
	Aug. 13–17	3♀♀ (T)
MacDill Field, Tampa, Fla.	Sept. 12–17	2♀♀ (T)
	Oct. 5	1♀ (T)
Welch Convalescent Hosp., Daytona Beach, Fla.	July 30	1♀ (T)
Camp Stewart, Hinesville, Ga.†	July 28	1♀ (T)
Mansonia titillans (Walker)		
AAF, Sarasota, Fla.	July 12	1♀ (T)
	Aug. 20	1♀ (T)
Orthopodomyia alba Baker		
Liberty Field, Hinesville, Ga.†	June 27, 1944	1♀ (T)
Psorophora cyanescens (Coq.)		
Camp Butner, Durham, N. C.	Aug. 4	1♀ (S)
Seymour Johnson Field, Goldlboro, N. C.	Sept. 10	1♀ (S)
AAF, Florence, S. C.	Sept. 10	2♀♀ (T)
Dale Mabry Field, Tallahassee, Fla.	July 18	1♀ (T)
Psorophora horrida (D. & K.)		
AAF, Marianna, Fla.†	May 28	3♂♂ (T)
Huntsville Arsenal, Ala.	July 25	1♀ (S)
Camp McCain, Grenada, Miss.	July 4	1♀ (S)
	July 11	1♀ (S)
AAF, Columbus, Miss.	July 4	1♂* (T)
Kennedy Genl. Hosp., Memphis, Tenn.	May 17	1♀ (T)
Psorophora varipes (Coq.)		
Camp Wheeler, Macon, Ga.	May 30	1♀ (B)
	June 6	1♀ (B)
	July 3–27	3♀♀ (B)
	July 26–31	2♀♀ (S)
Cochran Field, Macon, Ga.	May 19–24	9♀♀ (S)
	June 29	3♀♀ (S)
	July 6–Aug. 18	54♀♀ (S)
Chatham Field, Savannah, Ga.	July 13	2♀♀ (S)
Fort Benning, Columbus, Ga.	Aug. 20–23	2♀♀ (S)
Turner Field, Albany, Ga.	May 10	3♀♀ (S)
Charleston POE, S. C.	May 25	1♀ (S)
AAF, Columbus, Miss.	Aug. 7	1♀ (S)
Key Field, Meridian, Miss.	May 25	1♀ (S)

Table 1.—(*continued*)

SPECIES AND LOCALITY	INCLUSIVE DATES OF COLLECTIONS	SPECIMENS AND COLLECTION METHODS
Uranotaenia lowii Theobald		
AAF, Myrtle Beach, S. C.	Oct. 5	3♀♀ (T)
	Oct. 8	4♀♀ (T)
Craig Field, Selma, Ala.	Sept. 10–24	5♀♀ (T)
	Oct. 1–10	7♀♀ (T)

* Identified by genitalia.
† Previously unrecorded from state.

Aëdes cinereus, here shown to be present in Alabama, has now been reported for the first time in each of the southeastern states during the past 4 years.

Aëdes dorsalis has not previously been reported from any of the states comprising the Fourth Service Command althouth its wide range over the arid plains region of the United States extends as far south as El Paso, Texas, and includes two questionable Louisiana records. Identification of the specimen here reported from Mississippi was confirmed by Dr. Alan Stone of the U. S. National Museum.

The *Culex pilosus* unpublished record for 1944 is here included as it extends the known northwestern distribution for the species.

Past records of *Mansonia titillans* in the United States are of doubtful validity as recently shown by Pratt (in press) who discovered many specimens of *M. indubitans* among those which had originally been identified as *M. titillans*. New records are listed to supplement the summary of these species by Chamberlain & Duffey (1945).

An unpublished 1944 record of *Orthopodomyia alba* is included in this paper as a new state record for Georgia. The identification was verified by Dr. Alan Stone.

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DDT for Codling Moth Control[1]

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During the season of 1945, tests were made with DDT in a large commercial apple orchard at Mitchellville, Iowa, in comparison with lead arsenate for controlling the codling moth. *Carpocapsa pomonella* (L.) and other insects. The tests were designed (1) to demonstrate the efficiency of a rather heavy DDT spray schedule, extended well into the second brood period, and followed by lighter applications as harvest approached, and (2) to determine whether light applications of DDT could halt further increase of a codling moth population after it was well established.

The results of the codling moth experiments, and brief comments on the general insect infestation of the orchard, are given in this paper.

MATERIALS.—A dry commercial preparation[3] containing 40 per cent DDT and 60 per cent of inert material was used in all DDT sprays; a commercial ferric dimethyl-dithiocarbamate preparation[4] was incorporated in them whenever a fungicide was needed. All lead arsenate sprays contained commercial acid lead arsenate; to some of them a commercial summer petroleum oil[5] was added, and, as safeners, high calcium hydrated lime and zinc sulfate. Concentrated liquid lime-sulfur was employed in the preblossom spray, and wettable sulfur or ferric dimethyldithiocarbamate served as fungicides for the lead arsenate sprays.

PLOT ARRANGEMENT.—Two series of experimental plots were located in a part of the orchard consisting, principally, of trees of the following varieties: Red Delicious, Golden Delicious, Jonathan, Ben Davis, and Northwestern Greening. In the first series there were 12 rows of about 45 trees each, of which

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[2] The advice and assistance of Mr. Robert M. Clark, manager of the orchard, is gratefully acknowledged.

[3] *AK-40*, manufactured by the Geigy Company, Inc.

[4] *Fermate*, manufactured by E. I. duPont de Nemours and Company.

[5] *Superla*, manufactured by the Standard Oil Company of Indiana.

Table 1.—Comparative tests with DDT and lead arsenate in sprays for codling moth control (series I).

Dates of		DDT Sprays			Standard Lead Arsenate Sprays		
Application	Record	Ingredients per 100 gals.	Apples infested per cent	Blemishes per 100 apples	Ingredients per 100 gals.	Apples infested per cent	Blemishes per 100 apples
April 2–17 (Preblossom)	None	Lime-Sulfur 6 qts.			Lime-Sulfur 6 qts.		
May 2–11 (Calyx)	May 11	Lead arsenate 3 lbs. W. Sulfur 6.25 lbs. Lime 3 lbs.	None	None	Lead arsenate 3 lbs. W. Sulfur 6.25 lbs. Lime 3 lbs.	None	None
June 1– 2 (1st Cover)	May 31	DDT[1] 1 lb. Fungicide[2] 1 lb.	None	None	Lead arsenate 4 lbs. W. Sulfur 6.25 lbs. Lime 3 lbs.	None	None
June 11–12 (2nd Cover)	June 12	DDT 1 lb. Fungicide[2] 1 lb.	0.2	—	Lead arsenate 4 lbs. Fungicide[2] 1 lb.	0.5	—
June 20–21 (3rd Cover)	June 21	DDT 1 lb. Fungicide[2] 0.75 lb.	0	0	Lead arsenate 4 lbs. Fungicide[2] 0.75 lb. Oil 0.8 gal.	1.3	—
June 29 (4th Cover)	July 3	DDT 1 lb.	0	0	Lead arsenate 4 lbs. Lime 1 lb. Oil 0.8 gal.	4.3	—
July 18–20 (5th Cover)	July 19	DDT 1 lb. Fungicide[2] 0.56 lb.	0.2	—	Lead arsenate 4 lbs. Fungicide[2] 0.56 lb. Oil 0.8 gal.	10.8	15.2
Aug. 7 (6th Cover)	Aug. 10	DDT 0.75 lb.	0.6	—	Lead arsenate 4 lb.	14.0	20.9
Aug. 24–30 (7th Cover)	Aug. 28	DDT 0.33 lb. Lead arsenate 3 lbs.	3.7	3.8	DDT 0.33 lb.	27.7	52.0
—	Sept. 10	—	7.6	8.6	—	35.8	67.2

[1] All DDT dosages represent actual weight of DDT.
[2] Ferric dimethyldithiocarbamate (*Fermate*).

6 rows chosen at random received the DDT sprays throughout the season, and 6 rows received standard lead arsenate in 6 cover sprays, and DDT in the final spray. Single barrier rows, also sprayed with the standard mixture, separated the experimental rows from each other. The second series consisted of 2 rows of 45 trees each standing adjacent to the first series plots, and 2 shorter rows located at a greater distance. These rows were not randomized, were not separated by barrier rows, and were not accompanied by rows sprayed with the standard lead arsenate schedule because the objective of the experiment was to test the ability of DDT to halt the growth of an established infestation.

All spray applications were made by experienced operators with a power sprayer equipped with a tower that placed one spray gun fifteen feet from the ground, and in reach of the highest branches, and the other gun within easy access to the entire lower and middle parts of the tree.

Records and Criteria of Infestation.—Records were taken on six count trees in each row.

Table 2.—Results of tests with light applications of DDT following lead arsenate sprays for codling moth control (Series II). (Calyx spray to fourth covers spray, same as in table 1.)

Spray	Dates of:		DDT—Lead Arsenate Schedule		
	Application	Record	Ingredients per 100 gals.	Apples infested %	Blemishes per 100 apples
Calyx, 1st, 2nd, 3rd and 4th Covers	May 29 to June 29	—	See Table 1.	—	—
5th Cover	July 17	July 26	DDT[1] 0.25 lb. Lead arsenate 4 lbs. Fungicide[2] 0.56 lb.	10.8	15.0
6th Cover	Aug. 3	Sept. 7	DDT 0.25 lb. Lead arsenate 3 lbs.	27.2	41.2
7th Cover	Aug. 25	Sept. 24	DDT 0.33 lb.	31.5	52.8

[1] Actual DDT.
[2] Ferric dimethyldithiocarbamate (*Fermate*).

Except for the two short rows, the count trees were located at random within successive 7-tree levels along each row. Thus there were 36 count trees sprayed with DDT, and a like number sprayed with the standard schedule in the first series, and 24 count trees sprayed with lead arsenate-DDT mixtures in the second series.

Two criteria were used to assess the effectiveness of the sprays: (1) The number of apples entered, stung or otherwise damaged by codling moth larvae per 100 apples (percentage infestation); (2) the number of blemishes per 100 apples. Records were taken on random samples usually of 50 apples in each count tree without removing the fruit, a procedure that has furnished a reliable indication of effectiveness in previous seasons (Graham & Richardson 1940, 1942). Recordings were made in the first series plots after application of each spray, and in the second series plots after each of the last three sprays. These interim records furnished a continuous picture of the effectiveness of the spray materials as the season progressed.

RESULTS.—The results of the two series of experiments together with dates of spray application and recordings, and the composition of the spray mixtures are given in tables 1 and 2.

DISCUSSION.—In the first series plots (Table 1), DDT at 1 pound per 100 gallons held the first brood infestation almost at zero, and by July 19 the infestation was still negligible. Then the dosage was reduced, first to 0.75 pound per 100 gallons, and later to 0.33 pound (with lead arseante). At harvest (September 20) the infestation had reached 7.6 per cent. Probably a continuation of the 1-pound dosage of DDT in the last two sprays would have reduced the rather sharp percentage increase recorded near the end of the season. However, the control obtained with DDT was comparatively very good. The trees which received the standard lead arsenate sprays showed 4.3 per cent infestation at the end of the first brood period which increased to 14.0 per cent by August 10. Then, in an attempt to check further damage to a valuable crop, a 0.33-pound dosage of DDT was substituted for lead arsenate in the seventh cover spray, but in spite of this application, the infestation reached 35.8 per cent at harvest.

The plots in the second series (Table 2) were sprayed with the standard mixtures (Table 1) through the fourth cover spray followed by light applications of DDT in the succeeding three sprays. It is evident from the results that these light applications were not able to halt the upward trend of the infestation.

The results of the two series of experiments suggest that dosages of DDT as low as 0.25 and 0.33 pound, with or without lead arsenate, may not be sufficient to prevent definite increases in codling moth infestation. Graham (1945) reported that a 0.5-pound dosage of DDT failed to give good control, and Harman (1945) found that 0.8 pound was no more efficient than 3 pounds of lead arsenate. The results of this investigation appear to confirm the work of these authors.

No injury to fruit or foliage occurred in the DDT plots until late in the season. At that time a bronzing of the leaves, which however, was not accompanied by abnormal leaf fall, was observed only on Northwestern Greening trees. Examination of these trees at harvest failed to reveal the presence of mites themselves, or of webbing, eggs, cast skins or other indications of mite activity. It is believed that the injury was caused by DDT since it did not appear in trees sprayed with lead arsenate. It should be noted that petroleum oil was entirely absent from the DDT sprays.

GENERAL INSECT CONDITIONS IN THE ORCHARD.—Codling moths were first caught in traps on May 26. The trap records show the uninterrupted presence of small numbers of moths throughout the season with only one marked peak of emergence on August 28. The first codling moth larvae were seen on June 12. These larvae probably appeared after May 31 because a careful examination on that date failed to show a single entry or blemish. Compared with records of infestation taken in this orchard for the 4 years, 1939 to 1942, the latest available, the infestation of 1945 was of moderate degree.

The apple aphid (*Aphis pomi* DeG.) was present on mature trees in small numbers until mid July. Examination of the experimental rows on July 3 revealed a light aphid infestation, irregularly distributed, but with no tendency for greater abundance on DDT sprayed trees than on trees sprayed with lead arsenate. Leafhoppers (species not recorded) were scarce, and irregularly distributed throughout the experimental plots. Canker worms, green fruit worms and other leaf feeders were singularly absent. A few mites were seen in the latter part of the season; but nothing remotely suggestive of a mite infestation was observed at any time. Observations on a variety of the apple curculio (*Tachypterellus quadrigibbus magnus* List) will be published elsewhere (Richardson 1946).

SUMMARY.—Seven cover sprays of DDT (five of 1 pound per 100 gallons, one of 0.75 pound, and one of 0.33 pound with three pounds of lead arsenate) held an apparently moderate infestation of codling moth to 7.6 per cent damaged fruit at harvest. The infestation was nil during the first brood period, and increased most rapidly in the last part of the second brood period when the lower DDT dosages were used. A heavy lead arsenate spray schedule (three of the sprays contained petroleum oil), and one terminal cover spray of DDT gave 35.8 per cent of damaged fruit at harvest.

After a codling moth infestation became established in trees sprayed with lead arsenate (three cover sprays containing light doses (0.25 to 0.33 pound) of DDT were not able to stop its forward progress.

Aphids (*Aphis pomi*), leafhoppers and mites did not increase on plots sprayed with DDT.

Foliage injury, apparently caused by DDT, appeared late in the season as a bronzing of the leaves of Northwestern Greening trees. This injury was not observed on other varieties.—2-15-46.

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Distribution of Plum-Feeding Species of *Macropsis*

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In the course of studies to determine what insects are responsible for the transmission of the virus causing the phony peach disease, attention has been given from time to time to the possible insect vectors of certain other stone-fruit virus deseases, especially peach yellows. As a part of this study, a survey has been made to determine the southern limits of the distribution of *Macropsis trimaculata* (Fitch),[1] which is known to be a vector of peach yellows, and of certain other species of the same genus. Although for various reasons the survey is not complete, the information obtained thus far seems worth placing on record.

The role of *Macropsis trimaculata* as a vector of peach yellows was first announced by Kunkel (1933) and confirmed by Manns (1934) and Hartzell (1935). All three of these investigators tested other species of Homoptera with negative results, and while it is questionable whether enough tests have been conducted to completely vindicate these other species, the fact remains that, to date, only *Macropsis trimaculata* has demonstrated its ability to disseminate the disease.

The exact situation with regard to the plum-feeding species of *Macropsis* of the *trimaculata* type is not entirely clear. There are at least two distinct species, *trimaculata* (Fitch) and *insignis* (Van D.), that cannot always be distinguished by external characters, or by any known female character. In fact, *insignis* (Van D.) was considered to be a synonym of *trimaculata* (Fitch) until Breakey (1932) published his synopsis of the genus. As a result of studies of material collected in the course of our surveys, Oman has found still another form that may prove to be a new species or may merely be a variety of *trimaculata*.

To complicate the situation further these species frequently occur in mixed populations in plum thickets (as of *Prunus angustifolia*) or even on individual plum trees (as of *P. americana*). Consequently there can be little or no assurance that one is working with a pure population of *trimaculata* when transmission tests are carried on with collected insects. For this reason there seems to be a chance that more than one member of the *trimaculata* group may have been used in some of the reported tests, and may be capable of transmitting peach yellows. This possibility was recognized by Hartzell (1937), who stated, "As the species is variable both as to size and color markings, it is possible that future taxonomic study may change the present conception regarding its status." However this may be, Oman has advised that he examined all the material used in Manns' tests and that all of it was *trimaculata*. This confirms the role of *trimaculata* as a vector, but it still leaves open the possibility that *insignis* may play a similar role.

Two other plum-feeding members of the genus *Macropsis*—*tristis* (Van D.) and *quadrimaculata* Breakey—are of interest. *M. tristis* is quite distinct from the *trimaculata* group but has very similar habits and commonly occurs in mixed colonies with both *trimaculata* and *insignis*, at least through part of their range. This species seems to have received no attention as a possible vector of peach yellows. *M. quadrimaculata* is apparently less common than the other species under consideration, as it has been taken but four times in our survey. Breakey (1932) suggests that it may live on raspberry, but we have taken it only on wild plums.

Until Kunkel's paper was published, none of the species of *Macropsis* were considered to be of particular economic importance, and the genus had received only casual attention from collectors. Very little information was available as to the distribution of *trimaculata* and, if anything, even less with regard to *insignis* and *tristis*. Such records as had been published indicated that none of these species occurred south of the Ohio River in the Mississippi watershed, or south of the northernmost counties in Virginia east of the Appalachians.[2]

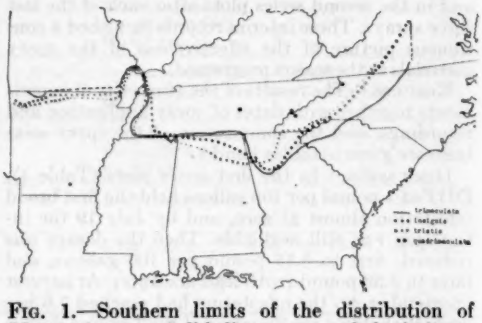

FIG. 1.—Southern limits of the distribution of *Macropsis* spp. Solid lines or symbols indicate definite records, while dotted lines and hollow symbols represent sectors in which our data are not complete.

Since sporadic outbreaks of peach yellows have occurred as far south as North Carolina and Tennessee, and particularly in view of the fact that since 1936 there has been an active, continuing epidemic of the disease through eastern Tennessee as far south as the Alabama line, it is evidence that the known vector must have a much wider range than has been reported, or that there is more than one vector. Of the two possibilities, the true range of the known vector was the more readily determined. Furthermore, a knowledge of the actual distribution of any vector of a disease is important to regulatory officials in that it indicates the area throughout which the disease may possibly become established insofar as the activities of that particular vector are concerned. For these reasons surveys were made from 1939 through 1942, to determine the southern distribution of all the plum-feeding species of *Macropsis*. These species have but one generation a year, and adults, essential to specific determination, are present only from about the first of June to the middle of August. Since they occurred in sufficient numbers to make surveying practicable only from the middle of June to the latter part of July in their southern range, and since it was necessary to fit the survey into a program dealing with other projects, only a limited portion of the boundary of the area of distribution could be determined each year.

Inasmuch as the primary hosts of the species of *Macropsis* under consideration are wild plums, par-

[1] The *Macropsis* specimens taken in the course of the survey were identified by P. W. Oman.

[2] Brimley (1938) published a record of the presence of *M. trimaculata* in the Blue Ridge at Swannanoa, N. C.

Table 1.—Southern distribution, by states and counties, of plum-feeding species of the genus *Macropsis*.

STATE AND COUNTY	*Macropsis*		
	trimaculata	*insignis*	*tristis*
Virginia:			
Amherst	x	—	—
Bedford	x	—	x
Halifax	x	—	—
Montgomery	x	—	—
Nelson	x	x	—
Pulaski	x	—	—
North Carolina:			
Cherokee	—	x	x
Clay	x	x	—
Davidson	x	—	—
Guilford	x	—	—
Henderson	—	x	x
Macon	—	x	—
Person	x	—	—
Rowan	x	—	—
Swain[1]	x	x	x
Watauga[1]	x	x	—
South Carolina:			
Oconee	x	—	—
Spartanburg	x	—	—
Georgia:			
Bartow	x	—	—
Catoosa	x	x	—
Chattooga	—	x	—
Cobb	x	x	—
Dawson	—	x	—
Fannin	x	—	x
Floyd	x	x	—
Forsyth	x	—	x
Fulton	x	x	—
Habersham	x	—	—
Pickens	—	x	—
Walker	x	—	—
Whitfield	—	x	—
Alabama:			
De Kalb	—	x	x
Etowah	—	—	x
Jackson	—	x	—
Limestone	—	x	—
Madison	—	x	—
Mississippi:			
Tishomingo	x	—	x
Tennessee:			
Bradley	—	x	x
Fayette	x	—	x
Franklin	x	x	x
Gibson	x	—	—
Greene	x	x	—
Hamilton	x	x	x
Hardeman	—	x	—
Hardin	—	x	x
Haywood	x	—	—
Lawrence	x	x	x
Lincoln	—	x	x
Loudon	—	x	—
Marion	x	—	—
Polk	—	x	x
Rhea	—	x	—
Sevier[1]	x	x	—
Shelby	x	—	—
Warren[1]	x	—	—
Wayne	—	x	x
Kentucky:			
Carlisle	x	x	—
Fulton	x	—	—
Hickman	x	—	x
Missouri:			
Butler	—	x	x
Cape Girardeau	x	x	x
Stoddard	x	x	x
Arkansas:			
Benton	—	—	x
Boone	—	—	x
Carroll	x	x	—
Randolph	—	—	x
Washington	—	x	x

[1] *M. quadrimaculata* collected in this county.

ticular attention was given to the plums rather than to peach. All species of wild plums occurring within the range of the insects appear to be natural hosts. Hartzell (1937) stated that *Prunus americana* was the favored wild host in New York, Connecticut, New Jersey, Pennsylvania, and Delaware, but throughout most of the territory we have covered *P. angustifolia* might be assigned that role. However, we have never noted any actual host preference where a choice was offered, and it seems probable that the apparent importance of any one species of plum in a given locality is due simply to its prevalence in that locality. We have collected *M. trimaculata* on *P. angustifolia*, on the form sometimes separated from *angustifolia* under the name *munsoniana*, and on *P. americana*, *hortulana*, and *umbellata*. *M. insignis* has been taken on *P. angustifolia*, *munsoniana*, *americana*, and *umbellata*, while known hosts for *M. tristis* are *P. angustifolia*, *munsoniana*, *hortulana*, and *americana*.

The counties that form the southern margin of the area of distribution of the four species of *Macropsis* included in the study are listed in table 1. The apparent southern limits of the distribution of three of the species are indicated in the map in figure 1.

In spite of the demonstration of a far wider range than had been credited to these species, the results of our surveys still suggest that they are primarily northern insects, their southern distribution appearing to depend largely on a combination of latitude and altitude. Thus, while in Georgia *trimaculata* was taken as far south as Atlanta, in North Carolina it was not found southeast of a line running from Charlotte (Mecklenburg County) to Roxboro (Person County). Again, while all three species were taken in the southernmost tier of counties all the way across Tennessee to the northeastern corner of Shelby County, none could be found in the immediate vicinity of the Mississippi River south of Carlisle County, Kentucky; nor could any be found in the delta counties of southeastern Missouri, although all three species were common and abundant in the hills just north and west of the delta. West of the Mississippi, however, altitude did not appear to be so important as farther east; for example, the southernmost records in Arkansas were limited to the northern tier or two of counties, in spite of the higher elevation in the Ozarks.

Further survey is needed between central Virginia and the Atlantic seaboard and from Washington County, Ark., west and north. Much more attention could also well be paid to the general and local distribution of all three species in those States where peach yellows is endemic.

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DDT to Control the Relapsing Fever Tick[1]

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During 1944, DDT spray tests were conducted in the laboratory for the control of the relapsing fever tick, *Ornithodoros turicata* (Dugés). Sprays were prepared by diluting two stock emulsions of DDT; (1) composed of 20 per cent DDT, 60 per cent Xylene, and 20 per cent *Triton X-100*, and (2) contained 10 per cent DDT, 12.5 per cent *Tetralin*, 2.5 per cent *Emulsifier B-1956*, and 75 per cent water. These emulsions are referred to in table 1 below, as *No. 1S.S.* and *No. 2S.S.* The percentage of DDT in the sprays ranged from 1 to 20.

Small cardboard cages 2 by 2 by 2 inches were used and 10 adult ticks were kept in each cage. Approximately 1 half inch of limestone clay or sand was used in cages containing litter. Each cage had a cardboard bottom and the top was covered with fine mesh bobbinet cloth which was held in place with adhesive tape to prevent the ticks from escaping.

Only one application of spray was made to each group of ticks. The spray was applied with a small atomizer sprayer. Ticks to be sprayed were placed in white enameled pans approximately 3 inches deep and 10 inches in diameter. The sprayed ticks were allowed to dry before placing them in the cardboard cages. Approximately 5 cc. of spray was applied to each group of ticks. Litter in cage 10 was treated by sprinkling the clay with the spray solution and stirring the medium with a glass rod. The litter was allowed to dry before ticks were admitted to the cage.

All cages were kept in a laboratory room where relapsing fever tick colonies have been maintained for several years. Daily examinations were made. The ticks were not fed throughout the experiments as they are commonly known to live several months without food.

SUMMARY.—The results as given in table 1 show that DDT sprays of 10 per cent and 20 per cent strengths were effective in killing relapsing fever ticks. Applying DDT spray directly to the tick does not appear to increase the effect of the insecticide. DDT of high concentrations is a promising insecticide for controlling these ticks, however, the cost and feasibility of applying it to natural conditions may be prohibitive. Field experiments are being conducted.—1-21-46.

[1] Stock solutions of DDT used in this experiment were made available by the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture, Washington, D. C.

Table 1.—Results of cage tests of DDT sprays against *Ornithodoros turicata*.

Treatment	Litter Used in Cage	Spray Applied to	Per Cent Net Mortality After Days							
			4	8	12	16	20	25	30	35
1% DDT No. *2 S.S.*	Sand	Ticks before placing in cage	0	0	0	0	0	10	10	10
5% DDT No. *2 S.S.*	Sand	Ticks before placing in cage	0	30	30	40	60	60	70	70
10% DDT No. *2 S.S.*	Sand	Ticks before placing in cage	20	30	60	60	90	90	90	90
Check No Treatment	Sand	None	0	0	10	10	10	10	10	10
1% DDT No. *1 S.S.*	Sand	Ticks before placing in cage	0	0	0	0	0	0	0	0
5% DDT No. *1 S.S.*	Sand	Ticks before placing in cage	0	0	20	30	40	40	50	50
10% DDT No. *1 S.S.*	Sand	Ticks before placing in cage	10	30	40	40	70	70	70	80
1% DDT No. *2 S.S.*	Limestone clay	Clay in cage before admitting ticks	0	0	0	10	10	20	20	20
5% DDT No. *2 S.S.*	Limestone clay	Clay in cage before admitting ticks	0	0	0	10	10	20	20	20
5% DDT No. *1 S.S.*	Limestone clay	To clay litter	0	0	0	0	20	40	40	50
Check No Treatment	Limestone clay	None	0	0	0	0	0	0	0	0
2% DDT No. *1 S.S.*	None	Ticks before placing in cage	0	0	0	0	30	30	40	40
20% DDT No. *2 S.S.*	None	Cheese cloth 3″×3″	100[1]							
10% DDT No. *2 S.S.*	None	Cheese cloth 3″×3″	10	20	40	40	50	70	100	
Check No Treatment	None	Cheese cloth 3″×3″	0	0	0	0	0	0	0	0

[1] All ticks were dead at end of the first day.

DDT as a Residual Insecticide for Fly Control in Barns

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During the season of 1945, tests were conducted to determine the effectiveness of DDT as a residual insecticide for controlling flies in barns under Oklahoma conditions. The various barns on the Experiment Station Farm presented an excellent opportunity for such procedure.

EQUIPMENT AND MATERIALS USED.—A kerosene spray was applied with a four-gallon garden-type tank sprayer. Water sprays were applied with a 20-gallon per minute Bean power sprayer using a four-disc type spray nozzle mounted on a T. Dusts[1] were applied with a single outlet hand crank duster. A technical grade of DDT was used in the kerosene spray. Niagara DDT-50 or Deenol-50-F were used in the water sprays. The dust was 10 per cent DDT in pyrophyllite.

The barns were of modern type construction with concrete floors, brick walls, and wood or concrete and steel stanchions.

PROCEDURE.—It was considered that a fairly accurate measure of the "active fly population" would be of paramount importance in interpreting the effect of any treatment. This was accomplished by using bait cards. Such cards were prepared by painting a solution of one part molasses in two parts vinegar over a square foot of surface area on heavy cards. Each card was freshly treated on the days records were taken. Four cards were used in measuring any given area. They were always placed in the same spots, which had been originally established by the fact that flies appeared to gather there more than anywhere else.

After the cards were in place, 5 minutes were allowed to lapse before the number of flies attracted to the baits were counted. An average of the counts on the four cards served as an index to the active fly population. Readings were made during the afternoon on three days of each week. Maximum temperature was also recorded at this time.

The first population readings were taken in the beef and dairy barns June 4. Daily records were kept for about 2 weeks. The first spray was applied June 8, in the beef barn. This spray was prepared at the rate of 7 ounces of technical DDT per gallon of kerosene.

Barns used in these tests were measured to determine the area treated. Sprays were all applied, as nearly as possible, at the rate of one gallon per 1000 square feet of area. The fly population in the untreated dairy barn was measured as a check until July 31, when this barn was treated with a 3 per cent spray. An expansion of the test program shifted the check to a swine barn which was more than a mile away from any of the other barns. Population readings were started here on July 23. At this same time, readings were begun in the cattle feeder barn and the main swine barn.

On July 31, 15,000 square feet (about 33 per cent) of the beef barn, all of the dairy barn (40,000 square feet), and all of the cattle feeder barn (25,000 square feet) were treated with water spray. A total of 55 gallons of spray containing 26.4 pounds of 50 per cent DDT was applied. This was a 3 per cent spray by weight. The cattle feeder barn received a more dilute spray, 2.5 per cent DDT by weight. The main swine barn and the swine feeder pen, approximately 20,000 square feet, were dusted with 20 pounds of 10 per cent dust.

On September 6, these treatments were repeated, using 5 per cent DDT in all sprays (12.8 ounces of 50 per cent DDT per gallon of water). The swine barn was again dusted at the same rate as before.

On July 17, readings were started in 10 henhouses which were within the fly infestation area of the beef and dairy barns. Two of these houses were sprayed with 4 per cent DDT in kerosene, two with 5 per cent DDT in water, and two with 10 per cent DDT in casein paint. The three different treatments were made July 19. Two of the houses were untreated and served as checks. Only the checks are shown graphically in figure 1.

RESULTS AND CONCLUSIONS.—Upon examining the graphs in figure 1, it will be seen that the initial fly populations in the beef and dairy barns were very much the same. This continued so until June 8, when the nursing wing of the beef barn was sprayed. Within a few hours, the average fly count dropped from about 100 flies to two or three. Fly control remained effective for about 2 weeks. During the third and fourth weeks it dropped off rapidly. On July 6, several head of cattle were sprayed in the beef barn with a 0.2 per cent water spray. The interior of the entire barn was also treated with this spray. A definite drop occurred in the fly population, but the control was effective for only 2 or 3 days.

The 3 per cent water spray applied in the dairy and beef barns on July 31 gave an excellent control for about 4 weeks. The slightly lower concentration of 2.5 per cent applied in the feeder barn lasted as long but was noticeably less effective. Good control was obtained by dusting a swine barn with 10 per cent dust at the rate of a pound per 1000 square feet. This control lasted for about a week, then dropped off rapidly. The untreated swine barn maintained a high fly population.

By September 6, it was evident that considerable effectiveness of the treatments had been lost in all barns. A follow-up 5 per cent spray was applied at this time in the dairy, beef, and feeder barns. This treatment practically eliminated the flies in those barns for the remainder of the season. A second dusting in the swine barn, however, did not prove to be so effective.

One very important factor which must be considered in these tests is the relationship between temperature and DDT control. On the graphs it can readily be seen that the rise and fall of populations was concurrent with the rise and fall of temperature. As temperatures dropped during the later part of the season, active fly populations also dropped. The great extension in time of control by using the 5 per cent spray therefore was not entirely due to increasing the amount of DDT used or to a cumulative effect of the two or more sprays, but rather, the sum total of all of these factors, indicating that the greatest duration of effective control would be realized when using the higher concentrate spray during periods of low temperature. Thus, the duration and effectiveness of control would be lessened as temperatures were increased and DDT concentrations were decreased. Such evidence indicates that the initial spray should contain about 5 per cent DDT since its control period would be during the warmer months of June, July, and August. The second spray, which should be applied about 6 to 8 weeks after the initial spray, could be reduced to 2.5 to 3 per cent DDT since its duration of control would extend

[1] Dusts were applied by Navy personnel.

into that part of the season when temperatures were dropping. It would also gain a cumulative effect from the initial spray.

Records of fly activity in the untreated henhouses which were in the vicinity of the treated barns show a very important interrelationship between the population in buildings within a given area. When flies were controlled in the barns, they also disappeared from the henhouses. This effect was so marked that it was not possible to draw clear conclusions concerning the relative value of oil sprays, water sprays, or DDT in casein paint. It was evident, however, that all three types of treatment killed flies for several weeks.

Some of the better homes in Stillwater are located along the south side of the college pasture and are within the fly population area of treated barns. Residents here noted the disappearance of flies after the DDT treatments and enthusiastically stated that they had never experienced such a fly-free season before.

SUMMARY.—DDT in oil, water, and as a dust was applied to the interior of barns. It was found that the duration and effectiveness of its control on the active fly population increased when the concentration of DDT was increased and temperatures decreased.

Little control was had using 0.2 per cent DDT. Excellent control was obtained with a 5 per cent spray. An influence of the fly population of untreated buildings within the area of treated buildings was very marked.—2-21-46.

Two Species of Thrips Non-Vectors of the Spotted Wilt Virus[1]

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Frankliniella sulphurea Schmutz[2] is a recent immigrant to the Hawaiian Islands, the first specimen having been collected in 1942 (Nishida 1943). This species is known to be widely distributed in the tropical zone. It is now thoroughly established on every major island of the Hawaiian Archipelago. This species is a general feeder, principally on flowers, with an extensive host range and is very abundant on the drier lowlands in the summer months. The details of its bionomics will be published in another paper.

An appearance of an immigrant species of the genus *Frankliniella* is highly significant in connection with the epidemiology of the spotted wilt virus[3] in Hawaii for the reason that several species of this genus are known to be vectors of this virus in other countries. The status of *F. sulphurea* in this respect has not been previously determined. A test to determine its transmitting ability was conducted in late 1942 and early 1943, immediately after its first discovery in the Islands.

Initially, field adults of *Frankliniella sulphurea* were collected, mostly from okra flowers, and of *Thrips tabaci* Lind., the sole known vector in Hawaii, from onion. Later, stock colonies of both species were developed on healthy *Emilia*. For each test both species were transferred together to the same diseased plant of *Emilia sonchifolia*, a major weed host of the virus. These source plants, experimentally or naturally infected, showed the typical symptoms of the virus commonly seen in the pineapple fields on the Wahiawa Plain. Both species bred freely on the vegetative parts of this host plant. The adults of each species of the next generation were recovered from the source plants and were separately transferred, three adults per plant, to healthy *Emilia* test plants. A total of 468 *F. sulphurea* and 543 *T. tabaci* from 18 colonies were transferred and 104 out of 181 plants of the *T. tabaci* series became infected but none of 156 plants of the *F. sulphurea* series (Table 1). This indicates that the virus in the source plants was in a state to be acquired and transmitted by *T. tabaci* but could not be acquired and transmitted by *F. sulphurea* which is thus proved to be a non-vector of the virus.

Anaphothrips (*Chaetanaphothrips*) *orchidii* (Moul-

Table 1.—Transmission tests of the spotted wilt virus from *Emilia* to *Emilia* by two species of thrips.

Colony No. On Source Plant	Number of Plants			
	Tested	Infected	Tested	Infected
	Frankliniella sulphurea		*Thrips tabaci*	
Series III				
1	10	0	2	1
2	17	0	6	4
3	8	0	5	2
4	2	0	4	3
5	5	0	5	3
6	6	0	5	5
Series IV and VI				
1	15	0	11	10
2	14	0	11	10
Series VII and VIII				
1	10	0	22	6
2	10	0	12	4
3	5	0	16	13
4	10	0	13	4
5	6	0	6	5
6	9	0	10	5
7	4	0	16	16
8	5	0	3	3
9	3	0	16	6
10	17	0	18	4
Total	156	0	181	104
	Anaphothrips orchidii		*Thrips tabaci*	
Series IX				
1	5	0	11	11
2	47	0	21	21
3	5	0	10	8
4	27	0	18	16
5	12	0	14	14
6	17	0	23	23
7	4	0	12	10
Total	117	0	109	103

[1] Published with the approval of the Director as Technical Paper No. 165 of the Pineapple Research Institute, University of Hawaii.

[2] Determined by J. C. Crawford and Dudley Moulton, independently.

[3] The virus known locally under the name of the yellow spot virus is identical with the spotted wilt virus with perhaps a different strain composition (Parris 1940, Sakimura 1940, Norris 1943).

ton) which has a wide host range and a wide distribution in the world is well established in Hawaii. The ability to transmit the spotted wilt virus was tested concurrently. This species also bred freely on the vegetative parts of *Emilia*. The same procedure for the transfer as used in the case of the first species was employed. A total of 351 *A. orchidii* and 327 *Thrips tabaci* from seven different colonies were transferred to the *Emilia* test plants, and 103 out of 109 plants of the *T. tabaci* series but none of 117 plants of the *A. orchidii* series became infected (Table 1). The data clearly demonstrated that this species cannot transmit the virus.

The writer previously reported *Thrips nigropuosus* Uzel and *Hercinothrips femoralis* (Reuter) are not vectors of the spotted wilt virus (Sakimura 1939), now two other species of thrips are shown to be in the same category.

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Baits for the Oriental Fruit Moth

R. D. Chisholm, W. P. Yetter, Jr., and M. H. Brunson, *U.S.D.A., Agr. Res. Adm. Bureau of Entomology and Plant Quarantine*

The search for a satisfactory attractant for the oriental fruit moth, *Grapholitha molesta* Busck., has resulted in the testing of several hundred compounds. Yetter & Steiner (1931) found that terpinyl acetate, technical grade, was efficient when used in combination with sugar solutions. Later these investigators[1] developed a bait mixture that has been used extensively. It was prepared by emulsifying the terpinyl acetate in a solution of saponin and mixing the emulsion with a solution of No. 9 medium-soft brown sugar. In 1942 Brunson[1] found that the efficiency of this bait was increased by the use of terpinyl acetate, extra grade. While this bait, used as the standard at Moorestown, N. J., is highly efficient and is easily prepared in the laboratory, it does not readily lend itself to a large-scale preparation by orchardists. Mechanical agitation is required to prepare the saponin-terpinyl acetate emulsion, which is foamy and difficult to measure. In an effort to facilitate the use of bait traps, two modifications of the standard formula have been developed that are easier to prepare and are less expensive. Rosin residue was added to one of these as a possible means of prolonging or enhancing attractiveness. Both modifications involve the preparation of an emulsible mixture of terpinyl acetate that is readily dispersed in water and then stirred into the sugar solution.

One of the emulsible mixtures (A) contained 3 grams (about 3 ml.) of a polyoxyalkylene derivative of sorbitan monolaurate (*Tween 20*) in enough terpinyl acetate, extra grade, to make 100 ml. of mixture. This is equivalent to 4 ounces of the *Tween 20* in 1 gallon of mixture. The second mixture (B) was prepared from 3 grams of the sorbitan monolaurate derivative, 10 grams of rosin residue,[2] and enough of the terpinyl acetate to make 100 ml. One gallon of this mixture contained about 1 pound of rosin residue. The ingredients are miscible in these proportions so that only stirring is necessary to insure a uniform mixture. The slight differences in the composition of the mixtures which would result from the use of the several units of measurement mentioned are not considered to be important.

In preparing baits from mixture A, 10 ml. of the mixture was shaken vigorously with 25 ml. of water (2 teaspoonfuls in about 1 ounce of water) in a tightly sealed bottle. The resulting emulsion was stirred into 5 gallons of sugar solution containing 4 pounds of No. 8 medium-soft brown sugar. One fluid ounce of mixture A is required for 15 gallons of bait. Baits were prepared from mixture B in the same manner except that 10 per cent more of the mixture was used to compensate for the substitution of rosin residue for part of the terpinyl acetate. All these baits contained terpinyl acetate at the rate of about 0.5 ml. per quart, a concentration which had been demonstrated to give the best results. The No. 8 sugar specified was used because the No. 9 grade, which had given best results in previous work, was not available owing to war conditions.

Orchard tests made during the summer of 1945 demonstrated that baits prepared from the two emulsible mixtures were at least as efficient as those made from the standard emulsion. All were tested at the specified concentration of 0.5 ml. of terpinyl acetate per quart of bait and at one-half this concentration. At both concentrations about 20 per cent more moths were caught in the traps containing mixture A than in those containing the standard. The traps containing mixture B, which contained rosin residue, caught about 30 per cent more than the standard.

All these tests were of a preliminary nature and were made in a lightly infested peach orchard under adverse weather conditions. The results appear to be sufficiently promising to justify suggesting substitution of mixture A for the standard bait on the basis of reduced cost, ease of preparation, and efficiency at least equal to that of standard. Further tests are planned for 1946 to establish the significance of the results and to determine the influence of the addition of materials such as rosin residue.—3-27-46.

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[1] Unpublished data.

[2] Rosin residue is also known as pine oil foots and is comprised prinicipally of polymerized terpenes of high molecular weight.

Use of Calcium Cyanide Solutions in HCN Toxicity Experiments with Insects

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The extensive use of hydrogen cyanide gas in insect control makes it desirable frequently to study the physiological action of this compound under controlled conditions. Liquid HCN is dangerous and difficult to control quantitatively without complicated equipment. Calcium cyanide-calcium hydroxide solutions may be used as constant sources of HCN gas with a technique which is simple, safe, and reproducible. The following article describes the method and gives examples of its experimental application.

PRINCIPLE OF METHOD.—A calcium cyanide solution saturated with calcium hydroxide has a definite HCN tension that is dependent upon its concentration and its temperature (Robbie & Leinfelder 1945a). The air space in a closed chamber containing some of the solution soon attains an equilibrium concentration of HCN which remains constant indefinitely under controlled conditions. It is thus possible to expose insect material to a selected concentration of cyanide gas by simply placing it in a chamber containing a small quantity of the appropriate cyanide-hydroxide mixture.

Table 1.—Concentrations of HCN gas given off by various solutions of calcium cyanide at 25° C. (Each contains 10 per cent suspension of calcium hydroxide.)

CONCENTRATION OF HCN GAS	EQUIVALENT CONCENTRATION OF $Ca(CN)_2$ SOLUTION
P.P.M.	Molar
750	1.30
500	1.08
250	0.74
100	0.39
50	0.23
25	0.12
10	0.05
5	0.026
2	0.011
1	0.006

PREPARATION OF CALCIUM CYANIDE.—Pure calcium cyanide is unobtainable, but a solution of calcium cyanide in calcium hydroxide can easily be prepared and is quite stable. A stream of air is led by suction from a water pump, first through a flask in which HCN is generated by dropping strong potassium cyanide solution into 50 per cent sulfuric acid, and then through a ten per cent suspension of calcium hydroxide. If the HCN is generated slowly about ninety per cent of it will be retained by the latter solution as calcium cyanide.

FACTORS AFFECTING GAS CONCENTRATION.—Table 1 shows the concentrations of HCN gas which are given off by various mixtures of calcium cyanide-calcium hydroxide at 25° C. If there is no change in pH the HCN tensions of the solutions will remain constant indefinitely, but under experimental conditions alterations in alkalinity may occur in two ways. Carbon dioxide given off by the experimental material may react with some of the dissolved calcium hydroxide to form carbonate. Since there is a large reserve of undissolved hydroxide present to maintain the solution level constant, no significant change in alkalinity results on absorption of carbon dioxide unless the rate of absorption is excessive. However, it is necessary to disperse the cyanide-hydroxide suspension on cotton or filter paper: otherwise the undissolved calcium hydroxide sinks to the bottom and leaves the exposed surface layer with no reserve hydroxide to replace that which is neutralized by carbon dioxide.

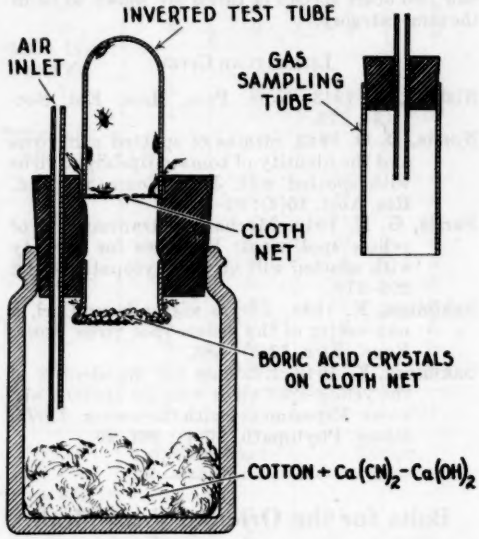

FIG. 1.—Exposure bottle used for testing effect of HCN on small insects. For details see text.

Change in pH also may occur because of ammonia formation as the calcium cyanide deteriorates. When the solutions are replaced occasionally and are refrigerated when not in use this factor is usually unimportant. In continuous exposure experiments the cyanide solutions should be changed at intervals of several days. A damp gauze covered with boric acid crystals will remove most of the NH_3 gas as it is liberated.

The HCN tensions of the cyanide mixtures increase with temperature, and within a range of 15° to 30° C. are roughly 5 per cent higher for each degree rise. The solutions listed in table 1 are for use at 25° C.; for other temperatures the concentration of cyanide gas in the air above the cyanide-hydroxide mixtures may be easily measured by the phenolphthalein technique (Robbie & Leinfelder 1945b).

HCN RESERVE OF CALCIUM CYANIDE SOLUTIONS.—The positive HCN tension of calcium cyanide-calcium hydroxide mixture is illustrated in table 2. A flat dish containing ten ml. of 0.34 M. calcium cyanide—10 per cent calcium hydroxide mixture absorbed on cotton was placed on the bottom of a seven liter museum jar, and at intervals air was withdrawn through a hole in the glass cover and the HCN content of the samples was measured. The

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analyses showed that the air at the top of the chamber was half saturated within ten minutes and that the saturation value attained in an hour was maintained for at least 21 hours. This rate was for simple diffusion of the gas; if the air is mixed by a fan the equilibrium state is reached very quickly. Since the concentration of cyanide in the liquid is tremendously higher than in the air, a volume as small as ten ml. is sufficient to saturate more than one hundred liters of air before its effective concentration is reduced 5 per cent. It is thus possible to open the cover of the testing chamber without reducing the equilibrium gas concentration appreciably.

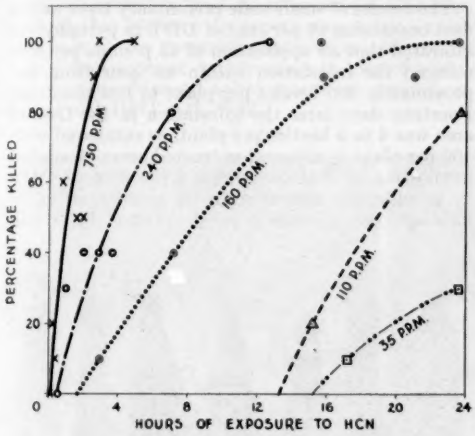

FIG. 2.—Results of HCN toxicity study on the bean beetle, *Acanthoscelides obtectus* (Say). The ordinate shows the percentage of insects killed at the various exposure times listed on the abscissa.

USE OF METHOD WITH SMALL INSECTS.—To measure conveniently the effect of a number of concentrations of HCN on small insects, the testing device shown in figure 1 may be used. The calcium cyanide-calcium hydroxide mixture is placed on cotton or filter paper on the bottom of a wide-mouthed bottle. A rubber stopper serves as the cover, and the bottom portion of a test tube, covered at the opening with thin cloth, contains the insects. When this tube is inverted into a hole in the stopper, it is quickly filled with cyanide gas. The concentration of HCN varies with the calcium cyanide concentration as shown in table 1, if the temperature is kept at 25° C. To check this level or determine the values at other temperatures, the tube containing the insects may be replaced by another piece of test tube, designated in the drawing as the sampling tube, and a measured sample of gas withdrawn in a glass syringe and analyzed. To prevent possible contamination by NH_3 gas, a filter of damp cloth covered with boric acid crystals may be interposed between the lower and upper chambers as shown in the drawing.

Table 2.—Saturation of air in 7-liter glass chamber by HCN diffusion from 10 ml. of 0.34 M. calcium cyanide-calcium hydroxide mixture.

TIME	HCN CONCENTRATION AT TOP OF CHAMBER
10 min.	42.3 parts per million
20	63.9
40	71.4
60	82.2
100	81.9
165	82.7
21 hours	82.0

ILLUSTRATIVE EXPERIMENTAL STUDIES.—Figure 2 presents some results that were obtained with the bean beetle, *Acanthoscelides obtectus* (Say), using the technique outlined above. For each test ten adult beetles were placed in the bottoms of the test tubes and the openings were covered with pieces of thin cloth. The tubes were then inverted and placed in the holes of the rubber stoppers in the calcium cyanide bottles. Exposures were made for various times as indicated. Since the insects may become stupefied by the HCN gas long before the lethal exposure has been reached, all of the test insects were left in room air for twelve hours after exposure before counts of survivors were made.

Table 3.—Development of 2-day post-diapause eggs of *Melanoplus differentialis* exposed to HCN gas from calcium cyanide-calcium hydroxide mixtures.

HCN	CONDITION AFTER THREE DAYS' EXPOSURE TO CYANIDE GAS	
Parts per million	Number developing normally	Number showing no development
20	10	0
40	5	5
60	0	10
80	0	10
100	0	10
140	0	10
Control	10	0

The effect of cyanide on the development of post-diapause eggs of the grasshopper *Melanoplus differentialis*, was determined in a similar fashion, and the results are presented in table 3. The eggs were exposed to the HCN gas on the second day after the start of post-diapause development and were left in the chambers with cyanide for three days. Comparison at that time with the control group kept under comparable conditions but without cyanide, showed that 60 parts per million of HCN is sufficient to prevent development at this stage but that 20 p.p.m. apparently has no retarding action. Test samples of gas withdrawn from the bottles at the end of the experiment and analyzed for HCN, showed that the cyanide levels were still within 10 per cent of the starting values.

SUMMARY.—Calcium cyanide solutions containing an excess of calcium hydroxide are convenient sources of HCN gas for quantitative experiments with insects. If a solution is absorbed on cotton or filter paper and kept in a closed chamber with the insect material, the concentration of HCN in the air will soon come to an equilibrium level which depends primarily upon the concentration of the calcium cyanide and the temperature. A series of calcium cyanide solutions with equilibrium HCN concentrations for 25° C. is listed. Illustrative experiments are reported.—4-5-46.

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Unusual Occurrence of the Corn Rootworm in Tennessee

L. B. SCOTT, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

In July 1945 adults of the corn rootworm, *Diabrotica longicornis* (Say), appeared in large numbers on midseason and late-planted river-bottom corn in and near Montgomery County, north-central Tenn. In one planting of approximately 300 acres, the infestation was estimated to be 100 beetles per plant. The insects infested all parts of the plants, but most of them were either under leaf sheaths, where they caused no apparent damage, or in the silks of the ears. It was not unusual to find 15 or more in the silks of a single ear. The silk masses of many ears were completely severed at or just beyond the tips of the husks, while those of other ears were only partially severed, the severed strands being held in approximately normal position by the uninjured ones.

Cursory observations disclosed no injury in the affected fields, but further examination in severely infested plantings showed that not more than half the kernels had been fertilized. Complete fertilization was observed in some ears from which all silks had been severed, an indication that they had been cut off too late to prevent fertilization. In general, however, fertilization was reduced in direct proportion to the loss of silks. In many ears imperfect fertilization was most evident midway between the shank and the tip. This fact suggested that silks attached to kernels at either end of the ears developed and served their purpose before or after insect injury occurred.

Damage increased until about August 15, when practically all silk masses were moderately to severely injured. Observations in several heavily infested plantings showed that only 50 per cent of the kernels had been fertilized (Fig. 1), and it appeared that some growers would not harvest more than half a crop. One grower planned to buy western calves and pasture them on 200 acres of damaged corn. However, observations on August 24 disclosed a marked reduction in infestation and a noticeable decrease in the number of unfertilized kernels. The infestation continued to decrease in September, disappeared entirely before October 1, and as the infestation decreased there was a corresponding reduction in unfertilized kernels. On October 1 approximately 95 per cent of the kernels had been fertilized, the unfertilized ones being distributed rather evenly among most of the ears, but many ears showed a wide variation in kernel development, ranging from the blister stage to the dough stage. It is doubtful whether the late-fertilized kernels would have matured in a normal season. However, heavy rains in September, totaling more than 4 inches, stimulated fall growth, and an unusually late fall provided conditions favorable for maturing the kernels. Killing frost did not occur until the last week in November.

Observations made when the crop was harvested disclosed more than the usual number of misshapen ears, many of which were found to have from a few to many unfertilized kernels. However, ears having more than 15 per cent of unfertilized kernels were rare No detailed examinations were made in the affected fields, but the results of rather careful observations by growers and by the author indicated that losses due to corn rootworm damage did not exceed 5 per cent.

The results of small-scale preliminary tests with a dust containing 10 per cent of DDT in pyrophyllite indicated that an application of 25 pounds per acre reduced the infestation within an hour from approximately 100 beetles per plant to less than one. Fourteen days later the infestation in the treated area was 4 to 5 beetles per plant, as compared with 100 per plant in adjacent untreated areas. A similar application of dust containing 3 per cent of DDT in pyrophyllite appeared to be equally effective, although the infestation in all infested fields had been reduced by natural causes to approximately 60 beetles per plant when the application was made. Twenty-four hours after the treatment with the 3 per cent dust, the infestation in the treated area was one-third beetle, as compared with approximately 60 beetles per plant in the check area. The infestation in the treated area 7 days after treatment was no more than one beetle per plant, as compared with four to five beetles per plant in the adjacent check area. The decrease in the check was due to natural causes and was noticed in all affected fields. No dead beetles were found in the areas treated with DDT.

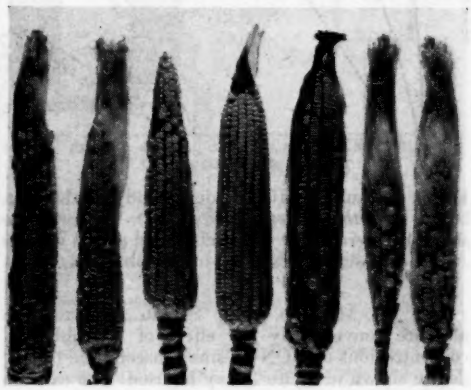

FIG. 1.—Imperfect fertilization of kernels resulting from injury to corn silks by adults of the corn rootworms. The silk of the central ear was damaged after the kernels had been fertilized. Clarksville Tenn., August, 1945.

An application of lead arsenate dust at the rate of 15 pounds per acre caused no noticeable reduction in the beetle population, but several dead beetles were found in the treated area. Neither lead arsenate nor DDT caused discernible plant injury.—4-4-46.

The Varietal Response of Cucumbers to DDT Control

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Preliminary tests of DDT spray and dust preparations for the control of cucumber beetles have been carried on by numerous investigators throughout the country. Their results[2] in general indicate that DDT is rather toxic to both the striped and the 12-spotted cucumber beetles. The degree of phytotoxicity varied from no injury at all to severe stunting of the plants. Most workers reported a serious outbreak of aphids following the use of DDT mixtures on cucumbers and other cucurbits. The purpose of this paper is to report somewhat similar results, with the exception that varietal differences were found to exist with respect to phytotoxicity and predisposition to aphid attack on cucumbers dusted with DDT in the field.

A small experiment to determine the value of DDT for the control of the striped cucumber beetle, *Diabrotica vittata* F., one of the vectors of bacterial wilt of cucurbits, *Bacillus tracheiphilus* EFS., was carried out at Geneva, N. Y. in 1944. The variety *China* was used. This variety is not grown comermercially to any extent but was used in this instance because of its resistance to mosaic disease. A calcium arsenate and a calcium arsenate-copper oxychloride sulfate dust, both of which are standard treatments for cucumber beetles in New York, were compared with a DDT dust. Each treatment was applied to a single row plot in random order in each of five blocks. Each plot was 28 feet long. The treatments were applied seven times at approximately weekly intervals during the period between the emergency of the seedlings and the formation of the first fruits. The number of plants killed by bacterial wilt and the yield of cucumbers were used as the criteria of the relative values of the three treatments. The plots were examined each week and all of the plants which were killed by wilt were pulled up and removed from the field. Yield records were also taken at weekly intervals beginning August 5 and extending to September 22.

All treatments resulted in a rather marked reduction in the percentage of plants killed by bacterial wilt. Likewise all treatments gave a considerable increase in yield, the DDT dust being superior to the other two treatments in this respect (Table 1). The decreased yields of the untreated plots appeared to result partly from the death of plants affected with wilt and partly from the stunting caused by the feeding activities of the beetles. There was no evidence of any plant injury from the DDT dust; in fact, the plants treated with this material appeared more vigorous than any others in the experiment (Fig. 1).

In 1945 the variety *China* was used again, and also included were the varieties *Chicago Pickling* and *Ohio 31*, the latter being tolerant of the mosaic disease of cucurbits. In addition to the three treatments compared in 1944 a new insecticide, dichlorodiphenyl dichloroethane[3] was also included in the experiment. The DDT dust was prepared from a concentrate[4] which contained 40 per cent of the active ingredient. The experiment was laid out in a factorial design with six replicates. Each plot consisted of a single row 16 feet long. The treatments were applied seven times with a hand duster of the bellows type, beginning when the plants emerged June 23 and continuing until the fruits began to form in early August. The striped cucumber beetle was abundant during the entire time the experiment was in progress and was particularly troublesome when the plants were in the seedling stage. The spotted cucumber beetle, *Diabrotica duodecimpunctata* F., was also present but in rather small numbers. Bacterial wilt was much more prevalent than in 1944.

In 1945 the results with DDT on the variety *China* were essentially the same as those obtained in 1944. Bacterial wilt control was outstanding and

FIG. 1.—Cucumber variety *China:* left, untreated; right, dusted with DDT.

[1] Approved by the Director of the New York Agricultural Experiment Station for publication as Journal Paper No. 665, February 2, 1946.

[2] B. E. & P. Q. 644. March 1945.

[3] *Z-89;* Rohm & Haas.

[4] *Gesarol.*

Table 1.—The effect of various insecticides on the percentage of bacterial wilt and the yield of cucumbers at Geneva, N. Y., 1944 and 1945.

		Bacterial Wilt				Yield			
Material	Concentration	China 1944	China 1944	Chicago Pickling 1945	Ohio 31 1945	China 1944	China 1945	Chicago Pickling 1945	Ohio 31 1945
		Per cent				*Pounds*			
Calcium arsenate[1]	10	3.3	16.7	18.0	16.0	79.0	17.0	18.0	29.6
Calcium arsenate + Copper oxychloride sulfate[2]	10 + 13.5	2.5	9.7	5.3	14.0	70.8	22.3	26.5	31.6
DDT	2	0.5	2.0	6.7	4.7	105.3	37.8	25.6	17.3
Z-39[3]	3	—	21.9	27.6	28.0	—	16.0	17.0	17.0
Check (No treatment)	—	15.9	34.0	35.8	26.7	30.7	8.3	9.4	14.0

[1] All materials were diluted with *Emteo* 23 talc.
[2] Contains 44 per cent copper.
[3] Supplied by the Rohm & Haas Company and now designated as *Rhothane*.

the yield of cucumbers was much higher than for any other treatment (Table 1). This, however, was not true of the other two varieties. The DDT dust gave very good control of wilt on *Ohio 31* but caused a very severe stunting of the plants of this variety. This was more evident when the plants were in the seedling stage but the condition persisted during the entire period the treatments were being applied. The plants made some growth when the treatments were discontinued but the yield was much reduced in comparison with the other dusts. Preliminary investigations in the greenhouse on the phytotoxicity of DDT indicate that all three varieties are injured when the DDT is applied as a spray, *Ohio 31* being more severely affected than either *China* or *Chicago Pickling*. No measurable injury occurred, however, when the DDT was applied as a 3 per cent dust. This might possibly have been due to the lack of a moisture deposit on the leaves. In the field experiment the DDT-treated *Chicago Pickling* plots grew well and appeared vigorous until about the middle of August when they became badly infested with the melon aphis, *Aphis gossypii* Glover. The leaves turned yellow, many of the plants died and the yield was reduced. The aphis infestation was rather general throughout the field but this was the only variety and the only treatment on which the insect was definitely injurious. The use of the combination of calcium arsenate-copper oxychloride sulfate gave somewhat better wilt control and better yields in most cases than the calcium arsenate dust when used alone. This is in accordance with the results obtained by Wilson & Runnels (1935) and Gould (1944). The 3-per cent dichloro diphenyl dichloroethane dust used in this experiment had little value as a control for cucumber beetles and bacterial wilt.

Summary and Conclusions.—DDT dust appears to have value for the control of the striped cucumber beetle and bacterial wilt and in general is more effective than the standard treatment involving the use of calcium arsenate and a copper compound. It was especially effective on the variety *China*. There are, however, certain limitations to the practical use of this material. It caused severe stunting of the *Ohio 31* variety and there may be other varieties which would react in the same way. There is also the problem of the excessive development of aphis following the use of this material on cucurbits. Before any commercial use can be made of DDT on cucumbers and related crops further study is necessary on the varietal susceptibility to injury and the factors which influence it. The apparent predisposition of some varieties to aphis development also seems to warrant further study.—2-6-46.

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DDT and Earthworm Populations

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One form of animal life that may be affected adversely by the widespread use of DDT as an insecticide is the earthworm. This is true especially of those species that drag fallen leaves and bits of other vegetation into their burrows for the purpose of feeding. Early in 1945 the writer had an opportunity to study the effects of DDT on earthworm activity. Observations were made in a dense stand of American elm, near Columbus, Ohio, part of which had been sprayed experimentally with DDT in September 1944.

In these experiments an emulsion containing 0.25 per cent of DDT with xylene and *Triton X-100* (an aralkyl polyether alcohol) was applied to the trees in a 50 by 50 foot plot with a high-pressure sprayer until it dripped from the foliage. Owing to drought in late summer and fall the elm foliage was in poor condition at the time of treatment, and the leaves soon began to fall. One month later the trees were bare and the ground beneath was covered with a mat of leaves. Drought conditions continued throughout the winter with very little precipitation before spring.

Since this stand had been observed annually since 1940 and heavy earthworm populations has been noted in it each spring, it was considered possible that the presence of DDT residues in the leaf carpet might be reflected in signs of feeding by these worms. When the stand was visited in mid-March 1945,

little earthworm activity was noticeable in either the sprayed or the unsprayed areas. When the stand was visited again 1 month later, however, in the unsprayed area earthworms had practically denuded the forest floor, leaving only the skeletal remains of leaves protruding from the middens that literally peppered the ground. In contrast, the ground surface in the sprayed area was still covered with a mat of leaves and only an occasional midden could be seen (Fig. 1). In fact, differences between the sprayed and unsprayed areas were so sharp that it was possible to detect the plot boundaries merely by noting the extent of the ground surface still covered with a leaf carpet. At this time a limited effort was made to compare the density of earthworms in the soil in the two areas by counting the worms in 2 feet of soil to a depth of 5 inches. In the sample taken from the sprayed area 27 worms were counted as compared with 95 from the unsprayed area. There were almost no immature worms in the sample from the sprayed area.

FIG. 1.—(Above) View of ground surface in unsprayed portion of American elm stand at Columbus, Ohio. Note earthworm middens and near absence of leaf litter. (Below) View of ground surface in sprayed portion of stand. Trees sprayed with DDT on September 19, 1944. Note absence of middens in this portion of the stand as compared with the unsprayed portion shown above. Photographs taken April 14, 1945.

Observations were continued throughout the month of May. The leaf supply in the sprayed area decreased gradually as the number of middens increased. By the end of the month the worms had dragged most of the leaves on the sprayed plot into their burrows, and there was no longer any noticeable difference between the sprayed and unsprayed portions of the stand. In other words, although the end result was the same throughout this stand, in that the 1944 leaf crop was eventually removed from the forest floor and devoured by earthworms, this was accomplished at a far more rapid rate in that portion of the stand not sprayed with DDT.—2-15-46.

On the Biology of the Cowpea Curculio in Virginia

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Only one generation of cowpea curculio, *Chalcodermus aeneus* Boh., occurred in each of two seasons at Chatham as contrasted with two generations in Alabama (Arant 1938) and two or more generations in Mississippi (Langston 1939). Average developmental time in peas in the field (egg to prepupa) at Chatham in two seasons was 16 days; average developmental time in the soil (prepupa, pupa, and adult) for the 2 seasons required 17 days. Winter mortality of hibernating adult curculios is high; only 2 per cent of 200 adults placed in outdoor hibernation cages survived the winter of 1944–45 at Chatham.

Although the tachinid parasite, *Myophasia globosa* (Tns.), has been recovered from cowpea curculio at Chatham, the most important natural control factor is the fungus *Beauveria globulifera* (Speg.) Pic.[1] This fungus attacks larvae, prepupae, pupae, and adults of the curculio. Although the fungus causes a high mortality of the insect in late summer and early autumn, adult curculios that have survived the hibernation period are by no means immune to fungus attack. The green muscardine fungus, *Metarrhizium anisopliae* Metsch.,[1] has also been found to infect and kill cowpea curculio at Chatham but it is secondary in importance to *Beauveria globulifera*.—1-9-46.

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[1] Identification of fungus diseases were made by Miss Vera K. Charles and Miss Flora G. Pollack, Div. of Mycology & Disease Survey, Bureau of Plant Industry, Soils, & Agricultural Engineering, U. S. Dept. of Agriculture.

Liquefied Gas Aerosols to Control Insects on Eggplant

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The eggplant lace bug *Gargaphia solani*, Heid. is probably the most important pest of eggplant in the eastern parts of Maryland. In some localities where horse nettle, *Solanum carolinense* L., the wild host plant, is abundant it is impossible to grow a productive crop of eggplant. The experiments described here were carried out in such an area.

Preliminary experiments on the control of this insect with DDT aeosols were carried out in 1944 and high kills were obtained (Smith *et al.* 1945). In 1945 the owner of the farm where the 1944 work had been done agreed to plant approximately a quar-

Table 1.—Summary of insect populations on treated and untreated eggplants throughout the season. Average number of insects per plant and per cent reduction.

DATE	TREATED	EGGPLANT LACEBUG	REDUCTION	POTATO BEETLE	REDUCTION	FLEA BEETLES	REDUCTION
June 21[1]	Yes	0.76		0.62		0.58	
22	Yes	0.02	97	0.00	100	0.00	100
30[1]	Yes	0.64		0.22		3.02	
July 2	Yes	0.42	34	0.12	45	0.44	85
7[1]	Yes	0.50		1.00		2.30	
	No	0.50		0.70		3.30	
8	Yes	0.02	96	0.24	76	0.06	97
	No	0.20	50	2.50	2.57[2]	1.20	63
27[1]	Yes	0.90		0.22		7.80	
	No	1.00		0.30		5.50	
30	Yes	0.54	40	0.08	63	0.58	92
	No	0 30	70	0.00	100	3.10	43
August 14[1]	Yes	33.08		0.10		1.66	
	No	15.80		0.00		7.70	
15	Yes	3.20	93	0.00	100	0.00	100
	No	12.20	22	0.20		1.20	84
29[1]	Yes	8.14		0.00		0.04	
	No	69.9		0.00		0.20	
31	Yes	0.38	95	0.00	—	0.08	100[2]
	No	67.20	10	0.00	—	0.90	350[2]

[1] Counts made immediately before treatment.
[2] Per cent increase.

ter of an acre of eggplant for aerosol treatment. Twelve hundred plants were set in June and the first aerosol treatment was made on June 21. Subsequent treatments were made on June 30, July 7 and 27, and August 14 and 29; though the crop continued through September no further treatment was necessary. The eggplants were adjacent to a field of maturing potatoes from which there was a heavy migration of flea beetles (several species) and Colorado potato beetles to the young eggplants. As the experiment was concerned primarily with the lace bug the entire field was treated with the first two applications of aerosol in order to save the young plants. When the rest of the treatments were made, 10 plants on one corner of the field were left as checks.

The aerosol solution used in this experiment contained 5 per cent DDT, 50 per cent methyl chloride, 5 per cent cyclohexanone, 5 per cent *Velsicol AR-60*, and 35 per cent acetone. It was applied with a three-nozzle hand-drawn dispenser. A 9-foot muslin trailer was used on the machine for the last three treatments. One nozzle directed downward was used in the first and second treatments; later when plants were larger two additional nozzles were directed inward toward the sides of the plants. The machine speed, 3 m.p.h. for the first four treatments, was slowed down by the large size of the plants in the last two treatments. Three and three-tenths pounds of aerosol was applied in each of the first two treatments, approximately 5 pounds in the third and fourth, and about 8 pounds in the fifth and sixth.

Population records were kept on the Colorado potato beetle, flea beetles, on which no attempt was made to segregate the species, and the eggplant lace bug. The results are given in table 1. In the table all stages except the egg are grouped. Figures are based on averages of 50 plant counts taken at random in the treated portion of the field, and the figures given for the check are averages of counts of the 10 plants.

The table shows that the greatest reductions of lace bug populations are indicated by the counts following the treatments of June 21, July 7, August 15 and August 29. Here reductions exceeded 90 per cent. Poorer results are indicated following the June 30 and August 27 treatments with only 34 and 40 per cent reductions. These later records were not taken the day following, but 2 and 3 days after treatment to allow for hatching of eggs and migration of adults into the field. Except for the last treatment this same trend in percentage reduction of the other two pests observed was apparent and was attributed to the migration of both species into the field during the period between treating and counting. There was some drift of insecticide onto the check plants as indicated, with two exceptions, by reductions of the species on the check plants after treatments. The effect of the lace bug infestation on the untreated plants could not be ascertained; these plants were uniformly smaller than the treated plants and generally lacked vigor, while treated plants were generally robust and healthy producing an excellent crop of high quality fruit.

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Effect of Sublethal Concentrations of Dinitro-*o*-Cresol on the Codling Moth

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Several experiments have been made in the course of studies on the use of 4,6-dinitro-*o*-cresol and stove-oil emulsion as a spray for destroying the full-grown larvae of the codling moth, *Carpocapsa pomonella* (L.), on the trunks and scaffold limbs of apple trees (Yothers *et al.*, 1943; Carlson & Yothers 1945, 1946a, 1946b; and Yothers & Carlson 1945). This paper reports the results of two experiments, one made in 1942 and the other in 1944, on the effect of sublethal concentrations of the material on the number of eggs laid by moths developing from larvae that survived the treatment, and on the viability of the eggs that were laid by such moths.

According to Heriot (1942), 14 of the 23 moths that developed from 100 larvae placed in corrugated paper strips treated with mixtures containing dinitro-*o*-cresol failed to deposit eggs. Gäbler (1943) reported that pupae of the nun moth, *Lymantria monacha* (L.), collected from areas dusted with a patented insecticide containing dinitro-*o*-cresol, contained an average theoretical number of 160 eggs as compared with 220 in pupae from untreated areas. The two lots of pupae produced equal numbers of moths, but the moths that developed from treated caterpillars produced only one-third of the potential number of eggs, whereas those from untreated caterpillars produced three-fourths.

Formulas.—The following formulas were used:

1942	
4,6-Dinitro-*o*-cresol	1, 2, or 4 pounds
Stove oil (viscosity 34 sec. Saybolt)	5 gallons
Sodium lauryl sulfate	4 pounds
Ethylene glycol monobutyl ether and trichloroethylene, 1:1 mixture	3 gallons
Water to make	100 gallons
1944	
4,6-Dinitro-*o*-cresol	1, 2, or 4 pounds
Stove oil (viscosity 34 sec. Saybolt)	15 gallons
A phthalic glyceryl alkyd resin (*Triton B-1956*)	½ pint
Hydrochloric acid (37% c.p.)	1½ pints
Finely divided diatomaceous earth (*Celite 209*) (Carlson & Yothers 1946a)	3 pounds
Water to make	100 gallons

METHODS.—The mixtures used in these experiments were prepared and applied in the laboratory, as a dip in 1942 and as a spray in 1944. For each test 6 cocooning sticks were treated with the material to be tested. The sticks used in 1942 were allowed to dry for 11 days and those in 1944 for 1 day, after which time they were fastened together in a bundle and placed in a can with 500 freshly collected larvae that were full grown. After the larvae had been allowed a few days to cocoon, the bundles were removed to wooden cages with glass fronts. Each cage was fitted with a roll of waxed paper for egg deposition (Eide 1936). In the 1944 experiment all cages were equipped with a drinking fountain for the emerging moths. These fountains were supplied with fresh water daily through a tube from the outside. A cage containing unsprayed bundles of sticks and the same number of larvae was operated each year as a check.

RESULTS.—The results of the two experiments are summarized in table 1.

Although the results in table 1 vary considerably for the two seasons, probably because of the variation in the formulas and in the length of time the cocooning sticks were held after treatment, their general trend is the same. The data indicate that codling moths developing from larvae that survive the application of sublethal concentrations of 4,6-dinitro-*o*-cresol deposit markedly fewer eggs than the moths that develop from untreated larvae, and also that the eggs deposited may be less viable than normal. These factors, combined with the toxicity of dinitro-*o*-cresol over a period of many months (Carlson & Yothers 1945, 1946b), appear to contribute largely to the control value of this material.

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Table 1.—Effect of sublethal concentrations of dinitro-*o*-cresol on full-grown codling mothlarvae.[1]

CONCENTRATION OF DINITRO-*O*-CRESOL	LARVAE PRODUCING MOTHS	MOTHS EMERGING		AVERAGE EGGS PER FEMALE	EGGS HATCHED
		Total	Females		
Pounds Per 100 gallons	*Per cent*	*Number*	*Number*	*Number*	*Per cent*
		1942 Formula			
1	27	133	70	5.3	71
2	20	100	50	3.0	66
4	1	5	3	1.7	100
Check (untreated)	29	144	63	16.0	70
		1944 Formula			
1	30	152	91	1.2	72
2	2.4	12	6	—	—
4	1.8	9	—	—	—
Check (untreated)	53	264	132	8.7	92

[1] In 1945, after this paper was written, a somewhat similar test of DDT 5 per cent gave similar results.

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Leaf-Feeding Sawfly Larvae Burrowing in Structural Wood

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During August and September of 1945, larvae of *Macremphytus* spp.[3] were found on dogwood foliage in several localities in Massachusetts. In September, three instances were investigated where mature larvae tentatively identified as *M. tarsatus* (Say),

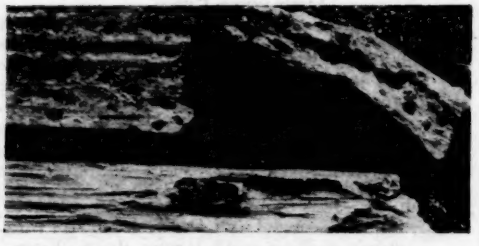

FIG. 1.—Wood injured in laboratory by mature larvae of *Macremphytus* sp. when burrowing to make pupal cells. Note frass (center and upper right) and pupal cells in cut-open piece of wood (below). One-half natural size.

were crawling about dooryards and on buildings in large numbers. They were burrowing into various wooden structures and objects to make pupal cells.

The burrowing varied from shallow pits, many of which had been abandoned, to deep holes in which larvae had completely embedded themselves. As might be expected, they usually made greatest progress in wood which was decayed or which was naturally soft and in such material embedded larvae were most abundant. Naturally, the home owners were greatly concerned.

[1] Agricultural Experiment Station.
[2] Massachusetts State College.
[3] Specimens were identified by Dr. C. F. W. Muesebeck of the Division of Insect Identification, Washington, D. C. or by Dr. H. H. Ross of the Illinois Natural History Survey.

Figure 1 shows wood which was injured by the larvae in laboratory.—3-7-46.

Dinitro-*o*-Cresol and DDT to Control Full-Grown Codling Moth Larvae

F. W. CARLSON and M. A. YOTHERS, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

Heriot (1942) and Carlson & Yothers (1945) have reported on the persistence of toxicity to cocooned codling moth larvae on apple trees of 4,6-dinitro-*o*-cresol (also called 3,5-dinitro-*o*-cresol) in a light mineral oil emulsion applied in March. This paper summarizes the results of tests made at Yakima, Wash., during the summer of 1944, to measure the persistence of toxicity of dinitro-*o*-cresol and DDT sprays to full-grown larvae of the codling moth, *Carpocapsa pomonella* (L.).

On July 18 approximately 6 quarts of several mixtures of 4,6-dinitro-*o*-cresol and one of DDT were sprayed on the trunks, crotches, and lower scaffold limbs (about 2 ft.) of each of three trees. Only fruitless trees were treated, to minimize the possibility of the presence of naturally occurring larvae. From 4 to 7 days after the spray was applied, 200 full-grown codling moth larvae, recently collected from bands elsewhere, were released on each treated tree. The same number of larvae were released on comparable untreated check trees, which remained undisturbed for 30 days except for superficial semiweekly examinations.

The larvae were confined to the treated area on the trees and other larvae were prevented from entering these areas by adhesive barriers and, in some cases, by adhesive-bordered cardboard platforms adjusted to the trunks near the ground. Corrugated-paper bands were placed above the adhesive barriers on the limbs and below them on the trunks to help prevent naturally occurring larvae from entering the treated area, but upon inspection no larvae were found. Twice a week all visible parts of the sprayed surfaces and all barriers were examined without disturbing any of the cocoons. Records were made of the living and dead larvae and pupae, and of the empty pupal cases. At the end of 30 days all rough bark was removed, and final records were made on the effectiveness of the treatments against the liberated larvae. At this time and again 30 days later—*i.e.*, 30 and 60 days after the sprays were applied—similar lots of larvae were placed on a comparable number of trees that had been sprayed at the same time as the first lot. These larvae were handled and observed in the same manner as those used in the first release. The results of these tests are given in table 1.

The toxicity of deposits from the regular dinitro spray (Formula 1, Yothers *et al.* 1943) persisted up to 90 days after the treatment had been applied. The deposits from the quick-breaking emulsion without a penetrant aid (Formula 2) killed only a small percentage of the larvae at any period. Formula 3, containing a finely divided diatomaceous earth, *Celite 209* (Carlson & Yothers 1946), in place of the regular penetrant, and Formula 4, in which the stove oil was omitted and bentonite substituted for the regular penetrant, effected a high kill during the first exposure period but did not during the later

Table 1.—Effectiveness of dinitro-*o*-cresol and DDT insecticides against full-grown codling moth larvae placed on trees at different times after treatment and then exposed for 30 days.

Formula No.	Formulation (Quantity per 100 Gallons of Spray)						Kill of Larvae Placed on Trees at Indicated Time After Treatment		
	Toxicant		Stove Oil	Emulsifier[1]	Penetrant		4 to 7 Days	31 Days	61 Days
		Pounds	*Gallons*	*Pints*		*Gallons*	*Per Cent*	*Per Cent*	*Per Cent*
1	Dinitro-*o*-cresol	4	10	4	—[2]	3	82	68	79
2[3]		3	15	0.5	(None)	—	39	50	46
3		4	15	0.5	Diatomaceous earth	*Pounds* 3	85	49	44
4		4	—	0.5	Bentonite	10	74	34	32
5	DDT[4]	4	—	0.5	Diatomaceous earth	2	85	28	20
	Checks (average of 3 trees for each period).....						16	24	16

[1] *Triton B-1956* (a phthalic glyceryl alkyd resin).
[2] Ethylene glycol monobutyl ether 6 quarts plus trichloroethylene 6 quarts.
[3] Formula included 3.78 grains of ferric chloride dissolved in 1 pint of water, which gave a quick-breaking emulsion.
[4] Dissolved in 3 quarts of benzene.

ones. An emulsion of DDT containing diatomaceous earth (Formula 5) gave a high kill (85 per cent) of the larvae exposed to it during the first period, but killed practically none of those exposured during the second and third periods.

Few larvae survived long enough to reach the pupal stage. It was not determined when or how the larvae and pupae were killed by the materials tested, as no cocoons were opened until the end of the exposure period. The manner in which they may be killed by the dinitro compound, as suggested by Heriot (1942) and by Carlson & Yothers (1935), is by contact or ingestion, or both.

These preliminary findings, substantiating results of somewhat similar tests made in 1945, indicate the possibility of greatly reducing the moth population in an orchard by applying a spray, such as the regular dinitro-*o*-cresol formula, to the trunks and lower limbs of the trees during the summer to destroy larvae that had already cocooned and those that might attempt to cocoon later. The safety of summer applications of the dinitro spray has not been fully determined.—4-4-46.

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A Penetrant Aid for Codling Moth Trunk Sprays

F. W. Carlson and M. A. Yothers, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*[1]

The desirability of incorporating a penetrating material in the trunk-spray formula containing 4,6-dinitro-*o*-cresol being developed for use against overwintering larvae of the codling moth, *Carpocapsa pomonella* (L.), was indicated by Yothers *et al.* (1942). A penetrant developed by Carlson, consisting of equal parts of ethylene glycol monobutyl ether and trichloroethylene, proved highly effective, but could not be recommended for practical use because of the unavailability and high cost of these chemicals during the war. The trunk-spray formula was modified (Yothers, *et al.* 1943) to produce a quick-breaking emulsion without a penetrant. This modified formula (Yothers & Carlson 1945) was less effective than the original formula with the penetrant, killing only 56 to 83 per cent of the larvae as compared with consistent kills of 84 to 89 per cent with the original formula.

Recent preliminary laboratory and field tests have shown that a finely divided diatomaceous earth,[2] of the type commonly used as a filter aid, may be a satisfactory substitute for the combination of ethylene glycol monobutyl ether and trichloroethylene as a penetrant in the trunk-spray formula. The diatomaceous earth forms a deposit which assists in the penetration of the dinitro-*o*-cresol-oil emulsion through the waxy cocoons to the larvae within. It is much cheaper than the original penetrant, costing only a few cents a pound.

[1] Acknowledgement is made to W. E. Westlake for suggestions and advice.
[2] *Celite 209* was used in these tests.

A new formula developed by the authors is as follows:

4,6-Dinitro-*o*-cresol	4 pounds
Stove oil	15 gallons
Emulsifiers[3]	0.5 pint
Diatomaceous earth	3 pounds
Hydrachloric acid[4]	1.5 pints
Acetone	6 pints
Water to make	100 gallons

In this formula acetone is used as a solvent for the dinitro-*o*-cresol. The dinitro compound can also be dissolved by heating, using 1 pound to each 6 quarts of stove oil. The hydrochloric acid is used to reduce the *p*H of the dinitro-*o*-cresol emulsion to between 2 and 4, the range within which it is most effective. The emulsion breaks on standing, but it reemulsifies with agitation; therefore, it is not necessary to empty a tank at each spraying.

The new formula, which contains 50 per cent more oil than the regular formula, gave kills of 99 to 100 per cent in the laboratory. In an orchard test in 1944 it gave 85 per cent kill as compared with 82 per cent for the regular formula, and in another test, in 1945, the kill was 78 per cent as compared with 87 per cent for the regular formula.—4-4-46

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[3] A phthalic glyceryl alkyd resin, *Triton B-1956*, was used.

[4] 37% c.p. acid was used, but any commercial concentrated hydrochloric acid would be satisfactory.

DDT to Control Rat Fleas

HARRY K. GOUCK, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

Preliminary studies were made at Savannah, Ga., in 1944–45 to determine the effect of DDT in reducing rat flea populations in buildings. The fleas observed in these studies were *Xenopsylla cheopis* (Roths.), *Leptopsylla segnis* (Schön.), *Nosopsyllus fasciatus* (Bosc.), and *Echidnophaga gallinacea* (Westw.).[1] All rats captured were brown rats, *Rattus norvegicus* (Erxl.). The fleas from rats treated with 10 per cent DDT dust in the laboratory became paralyzed and died. The treatment of rat holes and basement floors with 10 per cent DDT dust was followed by a sharp reduction in infestations of rat fleas in buildings.

A method was developed in the laboratory by which rats would constantly come in contact with DDT. Rodents have a natural tendency to run through tunnel-like structures; therefore, cylinders were designed to be used at entrances to rat holes and in frequented runways. These cylinders, 12 inches long and 3 inches in diameter, were made of a lightweight roofing paper. Dust containing 10 per cent of DDT in pyrophyllite was placed on a piece of cheesecloth 5 inches wide and 18 inches long and folded lengthwise. The folded cloth was inserted into the cylinder so that the ends of the cloth protruded through the ends of the cylinder and were fastened on the upper side. The cloth formed an elongated bag along the top of the cylinder and allowed the DDT to sift onto the rat as it rubbed against the bag in passing through. Infested rats were allowed to pass through cylinders containing 25 grams of the DDT dust, and other rats used as checks were passed through cylinders containing no DDT. All rats were then placed in cages over pans of water, from which fleas were collected at intervals. An advantage of this method is that the DDT within the cylinders is always accessible to the rats and remains clean, whereas in general dusting of floors and rat holes the DDT becomes contaminated with dirt and refuse.

Three separate tests were conducted in the laboratory. In the first test all fleas collected from three treated rats dropped within 3 hours after treatment. All were inactive when collected and were dead 48 hours after treatment. The fleas collected were 8 *Xenopsylla cheopis*, 15 *Leptopsylla segnis*, 4 *Neopsyllus fasciatus*, and 2 *Echidnophaga gallinacea*. No fleas dropped from an untreated rat until its death 48 hours after confinement, at which time four live, active specimens of *X. cheopis* were collected. In the second test all fleas collected from the treated rat dropped within 2 hours and 30 minutes after treatment. They were paralyzed when collected and all died in 48 hours. The fleas collected were 13 *X. cheopis*, 2 *L. segnis*, and 1 *N. fasciatus*. The fleas collected from the untreated rat dropped from 90 minutes to 48 hours after confinement. All were active at the time of dropping. There were two *X. cheopis* and five *L. segnis*. In the third test fleas collected from both the treated and the untreated rat dropped from 1 hour to 48 hours after treatment, and were dead 48 hours after dropping. The fleas from the treated rat, five *X. cheopis* and four *L. segnis*, appeared paralyzed when collected but those from the untreated rat, four *X. cheopis* and five *L. segnis*, were active when collected.

In two of the three tests the fleas on the treated rats were definitely affected by the DDT as they dropped from the host and showed paralysis at the time of dropping. The fleas on the check rats showed normal activity and were found at intervals in the moat.

FIELD TESTS.—An attempt was made to obtain a high degree of control of fleas in four poultry stores and one grain store in Savannah, Ga. These stores offered an excellent opportunity for tests because of a high incidence of flea-infested rats. Rats were trapped in three poultry stores in a vent-stopped block (where all possible rat entrances were closed except doors) consisting of seven stores and in a poultry store in an adjacent block not vent-stopped. For a week before treatment rats in the four stores were captured alive, killed, and bagged immediately. The bags with their contents were fumigated, after which the dead parasites were collected from the bags and combed from the rats.

Stores A, B, and C in the vent-stopped block were treated with 10 per cent of DDT in pyrophyllite, and store D in the adjacent block was used as the check. In store A the second floor was treated by

[1] Determinations made by H. E. Ewing and C. F. W. Muesebeck of this Bureau.

dusting 12 ounces of material into seven rat holes with a foot-pump duster. The dirt-floor basement (25 by 60 feet) was treated with 3 pounds of dust from a rotary duster, especial attention being given to the margins where rats were likely to run. The first floor, where chickens were dressed, was not treated. Store B was treated in the same manner as store A, 20 ounces of dust being used in 10 rat holes on the first and second floors and 4 pounds of dust in the basement (30 by 60 feet). Store C was treated by using DDT in cylinders as described for the laboratory tests. Twenty-four cylinders, each containing 25 grams of dust, were placed in likely runs and near rat holes in the basement (25 by 60 feet). Rats were trapped immediately after treatment and 14 and 51 days after treatment.

A second test was conducted in a grain store heavily infested with rats, but few were caught because of stacked grain and hay which made it difficult to reach the best trapping sites. The store had a floor space of about 2700 square feet and was treated by placing 36 cylinders, each containing 25 grams of 10 per cent DDT-pyrophyllite, in likely runs and near rat holes. Rats were trapped for 4 days before treatment, immediately thereafter, and 31 days after treatment.

The treatment with DDT dust was followed by a sharp reduction of rat fleas in the treated poultry stores. In treated store A control of *Xenopsylla cheopis* was almost complete for the 66 days after treatment. *Leptopsylla segnis* was almost completely controlled for 21 days after treatment, but was only 75 per cent controlled at the end of the 66-day period. No specimens of *Nosopsyllus fasciatus* were collected before treatment and only two during the 66-day period. *Echidnophyga gallinacea* showed complete control 21 days after treatment but no control at the end of the 66-day period. The absence of control of this species was attributed to the complete removal of fowls forcing the fleas to seek new hosts. In treated store B control of *X. cheopis* and *L. segnis* was almost complete for 66 days after treatment. *N. fasciatus* showed 89 per cent control at the end of the 66-day period. No *E. gallinacea* were collected during the entire test. In treated store C control of *X. cheopis* was almost complete for the 66-day period. *L. segnis* showed complete control 21 days after treatment but no control at the end of the 66-day period. *N. fasciatus* showed complete control at the end of the 66-day period and *E. gallinacea* complete control for the entire period.

In check store D, *Xenopsylla cheopis* showed a gradual decrease during the 66-day period and *Leptopsylla segnis* showed a gradual increase. No specimens of *Nosopsyllus fasciatus* were found during the entire period. *Echidnophaga gallinacea* showed a gradual increase during the period. In the treated grain store *X. cheopis* was almost completely controlled and *L. segnis* showed 94 per cent control at the end of the 33-day period. *N. fasciatus* and *E. gallinacea* were rare at all times.

SUMMARY.—A method was developed for charging cylinders with DDT so that the fleas on rats passing through them were killed by the dust. Rat fleas were greatly reduced in two poultry stores after rat holes and basement floors had been dusted with 10 per cent of DDT in pyrophyllite. Charged cylinders used in a poultry store and a grain store were slightly less effective than general dusting for the control of rat fleas, but the method avoids dangers encountered in general dusting in such places as grain stores.—3-20-46.

Codling Moth Traps in Oklahoma

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For several years entomologists and horticulturists of most apple producing states have been using codling moth bait traps to assist in the timing of codling moth sprays. By keeping trap records, they have found that it is possible to determine the rise and decline of codling moth populations in any given orchard. This, together with information as to the temperature reactions of codling moths and the length of time required for the hatching of eggs, has enabled them to so time sprays that the spraying has been recently completed and coverage is at its best at the time the largest numbers of newly hatched larvae were entering the apples. Therefore, entomologists of most apple producing sections either recommend the regular use of bait traps for the setting of spray dates or operate traps themselves and make use of the information thus obtained in setting spray dates for the growers of their areas.

Because so much work is conducted elsewhere on codling moth control and since Oklahoma is relatively unimportant as an apple producing state, Oklahoma entomologists have relied largely on the recommendations of others for codling moth control programs. Included in such recommendations is the use of bait traps for setting spray dates.

During 1942, a year of severe codling moth injury, complaints were received that the bait traps were trapping insufficient numbers of moths to be of use in setting spray dates. These orchards were visited in an attempt to determine the difficulty. Apparently the traps were properly made and hung and the baits were prepared and used according to recommendations. The number of moths trapped was very low, even though it was apparent that large codling moth populations were present. To obtain better information as to the difficulty, a series of traps were operated druing the balance of the season in the experiment station orchard at Stillwater. However, none of the traps consistently caught more than a very few moths, even though the infestation of the apples proved a high population was present.

It was therefore decided to obtain complete seasonal records on bait traps operated by the experiment station entomologists, to procure better information as to results to be expected from properly operated traps. The traps used were one-quart wide-mouthed fruit jars covered with quarter-inch hardware cloth. The bait consisted of a pound of brown sugar in each gallon of water and 1 or 2 drops of geraniol added to each trap. One week after the bait was prepared, 5 grams of sodium benzoate per gallon were added to the solution used in refilling the traps.

Table 1 shows the numbers of moths caught in 10 traps operated during the seasons of 1943, 1944 and 1945. The data indicate that, during the time and in the orchard in which this experiment was conducted, the traps were effective during the period of emergence of the spring brood of moths but were ineffective for the later broods. They also show that the total number of moths caught per trap was much lower during the emergence of the spring brood than the numbers reported trapped in more northern areas. In view of the fact that the apples in the orchard in which the traps were located suffered severe injury from codling moths, it appears that

Codling moth trap records at Stillwater, Okla. for 1943, 1944 and 1945.

Date	No. Moths Trapped 1943	1944	1945
Apr. 23	2		
24	8		
25	11		
26	26		
27	42		
28	40		9
29	38		2
30	56		4
May 1	75	9	6
2	9	3	20
3	12	0	0
4	16	7	0
5	24	0	7
6	20	0	36
7	13	9	5
8	1	23	0
9	3	4	5
10	0	9	3
11	0	41	3
12	3	20	1
13	0	32	0
14	0	40	1
15	0	48	0
16	3	45	0
17	0	69	0
18	0	20	0
19	0	17	8
20	0	0	2
21	2	0	0
22	1	0	0
23	1	0	0
24	2	0	2
25	0	2	1
26	0	0	3
27	0	0	0
28	1	0	1
29	0	0	1
31	3	1	2
June 1	0	1	4
2	0	0	6
3	0	0	0
4	0	0	0
5	4	1	0
6	0	1	0
7	3	2	0
8	2	1	0
9	0	1	0
10	1	1	0
11	2	1	0
12	1	2	1
13	0	4	0
14	0	0	1
15	0	0	2
16	1	1	0
17	0	2	0
18	0	1	2
19	1	1	1
20	0	0	0
21	0	1	0
22	1	0	0
23	0	0	0
24	1	0	0
25	0	0	0
26	1	0	0
27	1	1	0
28	1	1	0
29	1	0	1
30	2	0	0
July 1	2	0	0
2	0	0	0
3	0	0	2
4	0	0	0
5	0	1	1
6	2	0	0
7	0	0	0
8	0	1	1
9	0	0	2
10	0	0	0
11	1	1	0
12	0	0	0
13	0	0	1
14	1	0	0
15	0	0	0
16	0	0	0
17	1	1	1
18	1	1	1
19	0	1	0
20	0	2	0
21	0	0	0
22	0	1	0
23	3	0	0
24	1	1	0
25	1	0	1
26	2	0	0
27	5	0	0
28	1	0	0
29	0	1	0
30	1	1	1
31	2	1	4
Aug. 1	6	1	4
2	7	3	0
3	0	2	0
4	4	2	1
5	0	1	1
6	0	0	3
7	7	1	0
8	7	5	1
9	5	2	2
10	3	4	3
11	12	0	0
12	5	0	0
13	2	0	1
14	2	2	1
15	1	1	1
16	1	0	1
17	1	0	1
18	5	0	3
19	17	1	3
20	11	0	4
21	5	0	2
22	0	0	1
23	9	0	0
24	4	1	1
25	4	0	0
26	3	0	1
27	4	0	1
28	1	0	0

the comparatively small number of trapped moths was due to some factor or factors other than a small population of moths.

It is concluded that under the conditions existing in central Oklahoma, codling moth traps are useful in timing the application of sprays for the overwintering brood of moths but should not be relied upon for the timing of sprays for the later broods.—2-17-46.

Effects of Oral Dosages of DDT on Certain Vertebrates

HORACE S. TELFORD and JAMES E. GUTHRIE[1]

The investigations herein recorded on the toxicity of DDT to various farm animals were conducted at Ashland, Ohio, between the spring of 1944 and the summer of 1945. A summary of the acute toxicity is recorded in table 1.

In addition to these observations, 5 goats in lactation were given daily dosages of solid DDT in the feed or by stomach tube at the rate of 0.25 to 0.28 gram of DDT per kilogram of body weight for 21 to 29 days. All animals lost weight and the secretion of milk declined considerably. Two animals exhibited no tremors or other symptoms of intoxication. Three others exhibited light to moderate tremors. All recovered. Evidence for the transmission of DDT in the milk of these goats was presented elsewhere (Telford & Guthrie 1945; Telford 1945).

To determine if milk, butter or cream would become toxic at a lower dosage level, one goat in lactation weighing 50 kilograms was fed one gram daily of solid DDT in her feed for 2½ months. No symptoms of intoxication appeared in this subject or in her kid which suckled her mother *ad lib.* during the experimental period. Milk, butter and cream from this animal when fed to white rats from time to time produced no symptoms.

To determine the relative toxicity of DDT and dichlorodiphenyldichloroethane (DDD or *Rhothane D-3*), 10 young Barred Rock chickens were divided into 2 lots of 5 birds each. One group was fed 0.1 per cent DDT in their mash, while the other group received 0.1 per cent DDD in a similar manner. The chickens receiving DDT weighed between 320 and 446 grams, while the other group weighed between 358 and 488 grams. Both groups had ample feed and water before them at all times. All birds on DDT died within 3 to 10 days, exhibiting typical symptoms of DDT intoxication. One chicken from the group receiving DDD died on the 19th day. No symptoms were observed. No post-mortem lesions which could be ascribed definitely to the action of DDD were noted, although there was an edema around the heart. On the 29th day another chicken on the DDD feed died. No symptoms prior to death were noted. A post-mortem examination revealed:

1. A subcutaneous edema.
2. The pericardium was full of fluid.
3. Edema at the base of the heart.
4. The kidney tubules were full of urates.

The remaining 3 birds lived for approximately 2 months on 0.1 per cent DDD diet with apparently no harmful results.—3-24-46.

[1] Entomologist and veterinarian respectively of Dr. Hess & Clark, Inc.

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Table 1.—Oral toxicity of single doses of solid DDT to goats, chickens and a horse.

ANIMAL	WEIGHT KILOS.	DOSAGE GM. PER KILO.	REMARKS
Goat, female	38.5	1.5	Administered with stomach tube. Mild tremors. Recovered.
Goat, female	49.8	1.5	Administered with stomach tube. Mild tremors. Recovered.
Goat, young female	22.2	2.2	Administered with stomach tube. Moderate tremors. Recovered.
Goat, female	42.6	2.8	Administered with stomach tube. She exhibited severe tremors and became prostrate within 52 hours. She was then destroyed. This animal was in poor condition at the beginning of the experiment.
Goat, young male	17.2	2.9	Administered with stomach tube. Light tremors. Recovered.
Goat, young female	24 9	3.3	Administered with stomach tube. Moderate to severe tremors. Recovered.
Goat, male	57.9	5.5	Administered with stomach tube. Severe tremors and convulsions. Down and could not rise on the 13th day. He was then destroyed.
Goat, male	38.5	6.5	Administered with stomach tube. Severe tremors. Died on 16th day.
Horse, gelding	561.7	0.26	Administered in feed. No symptoms.
Chicken, W. Leghorn	2.25	0.44	Administered in gelatin capsules. No symptoms. Some of these hens laid eggs following treatment.
Chicken, W. Leghorn	2.16	0.46	
Chicken, W. Leghorn	2.57	0.39	
Chicken, W. Leghorn	2.38	0.42	
Chicken, B. Rock	1.44[1]	0.35	Administered in gelatin capsules. No symptoms. All birds gained weight following treatment.
Chicken, B. Rock	1.51[1]	0.49	
Chicken, B. Rock[2]	1.44[1]	0.35	

[1] These are weights of fasted birds just prior to administration.
[2] This subject also received 0.35 gm. per kilo. of stannous maleate.

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Earworm Control on Sweet Corn

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The application of mineral oil plus a suitable insecticide directly into the silk mass of individual ears has proved a promising means of protecting sweet corn from injury by earworms. For a detailed review and bibliography on this subject, the reader is referred to recent reports by Carruth (1942), Wilcox (1943) and Barber (1944).

Tests were conducted at Lincoln from 1941 to 1945, inclusive, to evaluate oil and certain other individual ear treatments under Nebraska conditions.

TREATMENTS.—Treatments consisted of: a, white mineral oil, U.S.P. grade with a viscosity of 200–250; b, mineral oil, viscosity 100–150, plus 0.2 per cent pyrethrins; c, mineral oil (same grade as in b) plus 2.0 per cent dichloroethyl ether; d, desilking; e, 33 per cent cryolite dust (1943); f, mineral oil containing 2 per cent styrene dibromide[2] (1945); and g, 5 per cent DDT-pyrophyllite dust (1944 and 1945). A hybrid strain of the variety Golden Cross Bantam was used in all tests.

METHODS.—Oil and oil-insecticides were applied by means of a commercial pistol-grip applicator at about the time the tip of the silks began to turn brown and wilt, or approximately 5 days after silk exposure. The dosage was 0.75 ml. in 1941 and 1942 and 0.50 ml. in later tests. Desilking consisted of removing with shears about a half-inch of husk. Additional cuts were made whenever the characteristic brown discoloration indicated a deeper penetration of the larvae. Two trips were made through the field at 4 or 5 day intervals. The cryolite and DDT dusts were applied at the rate of approximately 0.06 ounce per ear with a small (4 ounce) single hand bellows duster. An ear could be grasped with one hand while using the other to inject the dust directly into the tip of the silk mass through the small nozzle of the duster. Only one trip through the field was necessary since the dust could be applied any time after the silk appeared. In addition, DDT was applied to the silks and tips of ears by means of a small plunger-type duster.

HARVEST RECORDS.—Three degrees of insect injury were recognized: 1, no earworm injury—this included any ears, at most a small proportion of the total, which became infested but showed no signs of actual damage; 2, tip injury—damage confined to outer one third of ear; and 3, severe—damage extended beyond outer third of ear.

RESULTS.—The results of the experiments from 1941 to 1943 inclusive are summarized in table 1. Reference to the table will show that very little if any advantage was obtained by desilking. In 1941 and 1942 oil alone gave a significant increase in clean ears and in 1943 it was equal to oil-insecticide combinations. Oil-pyrethrum and oil-dichloroethyl ether were equally effective and during two of the three years superior to oil alone. During the one season's test cryolite dust was as effective as oil-insecticide combinations. An appreciable amount of tip stunting was caused by the oil and oil-insecticide combinations. No damage to ears by the cryolite dust was observed.

Experimental sweet corn plantings were made on three different dates in 1944 and 1945, but the percentage of earworm infestation was not high enough (less than 25 per cent) to give a critical control test. Treatments were made in some instances and observations made on phytotoxicity. No injury by the DDT was observed.

DISCUSSION.—In general the results of these tests are in agreement with those obtained by a number of others in similar tests. The degree of control obtained, however, was lower in some instances. The relatively poor control obtained by desilking is contrary to the findings of Emmert & Price (1942) who reported that in Kentucky desilking was more effective and economical than oil-pyrethrum. Ditman *et al.* (1941) also found desilking to be comparatively effective in Maryland, particularly for light infestations.

Table 1.—Results of 1941, 1942, and 1943 experiments on earworm control at Lincoln, Nebraska.

TREATMENT	TOTAL EARS EXAMINED[1]	EARS WITH UNINJURED KERNELS PER CENT	TIP STUNTING INCHES
	1941		
Untreated	179	34	
Desilking	174	40	
Oil, alone	196	67	
Oil+0.2% pyrethrins	165	81	
Oil+2.0% dichloroethyl ether	187	79	
Difference necessary for sig. at 5% level =		11	
	1942		
Untreated	268	57	less than 0.5
Desilking	233	52	less than 0.5
Oil, alone	224	73	1.47
Oil+0.2% pyrethrins	225	86	1.15
Oil+2.0% dichloroethyl ether	232	81	1.49
Difference necessary for sig. at 5% level =		16.8	
	1943		
Untreated	308	55	
Desilking	189	63	
Oil, alone	198	71	
Oil+0.2% pyrethrins	201	72	
Oil+2.0% dichloroethyl ether	223	72	
Cryolite (33% dust)	278	73	
Difference necessary for sig. at 5% level =		11.7	

[1] 1941 = 3 replicates.
1942 = 5 replicates.
1943 = 3 replicates.

The results of these tests indicate that the earworm on sweet corn can be successfully controlled under Nebraska conditions by individual ear treatment with oil or oil-insecticide combinations. There are, however, certain complicating factors. Wide yearly and seasonal fluctuations in earworm populations make it desirable for the grower to determine the extent of infestation as well as the correct time to apply treatment in order to get control and still

[1] Acknowledgment is made of the assistance of Edward C. Klostermeyer and Doris B. Gates, and the cooperation of H. O. Werner, Dept. of Horticulture.

[2] *Dowspray No. 9.*

avoid injury to the ear. Such determinations can be readily established by a trained worker, but the average home gardener or truck gardener is likely to have difficulty deciding such questions with certainty. With the unfavorable growing conditions for sweet corn which frequently exist in Nebraska, silking is often irregular and prolonged. This necessitates additional trips through the field, encourages premature treatment, and hence tip stunting, all of which limit practicability.—2-2-46.

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Gynandromorphism in *Culex nigripalpus*

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Gynandromorphism has previously been reported from this laboratory in *Culex pipiens-quinquefasciatus* and *Culex quinquefasciatus* by Middlekauff (1944). A third gynandromorph was mentioned in that paper but was lost before it could be described. The reporting of the present specimen brings the total to four adult mosquitoes exhibiting gynandromorphic characteristics out of a grand total of approximately 1,644,050 adult mosquitoes identified at the Fourth Service Command Medical Laboratory, Department of Entomology from 1942 to 1945 inclusive.

On October 2, 1945 during the routine identification of a mosquito collection from Hunter Field, Savannah, Georgia an aberrant specimen of *Culex nigripalpus* Theobald was noted and upon further examination it was recognized to be a gynandromorph. The specimen was collected from a New Jersey type electric light trap along with three normal males and 10 normal females of *C. nigripalpus* on September 28, 1945.

This unusual specimen possessed typical male antennae and palpi; the legs and wings were proportionately more slender, as in normal males, than analogous female structures. The genitalia, size and shape of the abdomen and abdominal scale pattern were characteristically female. The specimen has been deposited in the United States National Museum, Washington, D. C.—4-4-46.

[1] First Lieutenant, Sanitary Corps, A.U.S.

[2] It is desired to express appreciation to Miss Winona Gilstrap, Medical Technician, SP-5, for bringing this specimen to the author's attention.

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The Cucurbit Midge, *Itonida citrulli*

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On July 26, 1932, a curled condition of tips of watermelon vines was brought to the attention of the writer while visiting a field of this crop near Marana, Arizona. At that time a very small number of injured tips of vines were collected. From this small amount of material were subsequently reared some adults of a species of gall midge of the Family Cecidomyiidae (Itonididae). Specimens were sent to the late Dr. E. P. Felt who recognized it as a new species. More specimens were reared in 1933 and 1934, and together with notes were sent to Dr. Felt for his use in preparing a description of the species. Felt (1935) then named the insect *Itonida citrulli* n. sp. and published the description. The common name "cucurbit midge" was first suggested by Dr. Wyatt W. Jones, formerly of the Phelps Dodge Corporation of Douglas, Arizona. Since this insect affects other cucurbit plants the name seems appropriate.

The origin of the cucurbit midge is not known. It has undoubtedly been present in the Santa Cruz Valley of Arizona for many years. It is believed to have been present in the Marana area for at least three years before the adult was reared from infested tips of watermelon vine from that area in 1932. The injury characteristic of the insect is said to have been observed on watermelon in the Tucson area about 1924.

DISTRIBUTION.—The cucurbit midge is presently known to occur only in Arizona, where it is known from the vicinity of Tucson, Rillito, Marana, Phoenix and Douglas. Specimens have been reared from these localities by the writer. Its work is said to have been observed also at Mesa and Hereford. So far as is known this insect is limited in its distribution to those areas in which definite summer rains occur and where irrigation is practiced.

FOOD PLANTS.—The cucurbit midge feeds upon the tips of the vines of cultivated watermelon, *Citrullus vulgaris* Schrad. and upon its ancestor and near relative, the wild African watermelon, *C. vulgaris* Schrad. It also feeds upon the vines of squash and pumpkin. The writer has failed to find this insect on cantaloupe, *Cucumis melo* L. However McKinney (1939) records it on cantaloupe and cucumber as well as squash and watermelon. The writer has examined two species of wild gourd, *Apodanthera undulata* Gray, and *Cucurbita digitata* Gray, but has found no evidence of the presence of this insect.

INJURIES.—The injury which is caused by this insect, although obscure and easily overlooked, is nevertheless serious. On watermelon numerous tiny pale green or yellowish larvae are found among the fine hairs and buds at the tip of the vine. They evidently rasp the tender green tissues with their mouthparts and feed upon the plant juices and tender green plant material. This habit results in the formation of irregular brown scars on the calyces of the developing buds and on the tiny stems of the

buds. Growth is checked and the tips of the vines become compact and may become bent over, curled or kinked. The affected tips soon turn brown and die and have the appearance of having been burned or frosted. The terminal tip of the vine as well as the tips of the side branches may be attacked. If the vine develops a second or third growth of tips these may also be attacked. The killed tips are somewhat hidden by the leaves of the vines while newly infested tips or tips which are free of infestation are always noticeable above the leaves. The pruning effect resulting from this work seems to reduce the set of melons.

In squash the larvae attack the live green buds or tips near the center of the plant and the growth of the vines and the production of fruit is arrested. This constitutes the most serious injury. However any green tissue that is folded or forms a crevice seems to be a point of attack so long as the tissue remains green, but dry plant tissue is never attacked. The larvae attack unopened buds, the axils of buds, and young leaves which have not yet unfolded or which are partly unfolded. Later these leaves have a ragged torn appearance due to holes along the ribs and along the edges, together with a puckered and crinkled appearance which is caused by the larvae. The holes in the leaves are of irregular shape and size and the tissue around the holes may turn yellow. Italian summer squash is said to be most susceptible, with yellow crook-neck summer squash ranking next, while white scalloped summer squash is least susceptible. In September 1943 the writer was informed that this insect had ruined the summer squash crop of 1943 in the Hereford area. In November 1944 the writer learned that the growing of Italian squash, yellow crook-neck squash, and white scalloped summer squash was discontinued in the Douglas area because of the work of this insect.—4-1-46.

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The Toxicity of Certain N-Substituted Phenylhydrazines to Codling Moth Larvae

E. H. SIEGLER and S. I. GERTLER, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

Certain N-substituted phenylhydrazines were tested for their possible insecticidal value against newly hatched larvae of the codling moth, *Carpocapsa pomonella* (L.). These compounds were prepared by the reaction of phenylhydrazine with the required acid or acid chloride under suitable conditions. They consisted mainly of phenylhydrazides of aliphatic acids, with some aromatic and sulfonic acids. All compounds but one have an acyl group attached to the nitrogen, which has two replaceable hydrogens; the exception has the same group attached to each nitrogen.

The insecticidal evaluations were obtained with the apple-plug method under laboratory conditions. All compounds were used at the rate of 4 pounds to 100 gallons of the carrier, which consisted of water 80 per cent and ethanol (95 per cent) 20 per cent by volume. From 90 to 107 apple plugs were used for each of the organic compounds and approximately 900 plugs each for the lead arsenate and check tests. A single ready-to-hatch egg of the test insect was enclosed with each apple plug.

The results are shown in table 1, in which the organic compounds have been arranged in the order of their toxicity. 1-Isovaleryl-2-phenylhydrazine was slightly superior to lead arsenate, and the next four compounds—namely, 1-acetyl-2-phenylhydrazine, 1-(*m*-nitrobenzoyl)-2-phenylhydrazine, 1-iso-

Table 1.—Toxicity of certain N-substituted phenylhydrazines to codling moth larvae.

COMPOUND	FORMULA	PERCENTAGE OF APPLE PLUGS	
		Wormy	Stung
1-Isovaleryl-2-phenylhydrazine	$C_6H_5NHNHCOCH_2CH(CH_3)_2$	46	6
1-Acetyl-2-phenylhydrazine	$C_6H_5NHNHCOCH_3$	57	7
1-(*m*-Nitrobenzoyl)-2-phenylhydrazine	$C_6H_5NHNHCOC_6H_4NO_2$	62	4
1-Isobutyryl-2-phenylhydrazine	$C_6H_5NHNHCOCH(CH_3)_2$	63	1
1-Phenyl-2-stearoylhydrazine	$C_6H_5NHNHCO(CH_2)_{16}CH_3$	63	4
1-Benzoyl-2-phenylhydrazine	$C_6H_5NHNHCOC_6H_5$	68	2
1-Butyryl-2-phenylhydrazine	$C_6H_5NHNHCOC_3H_7$	68	2
1-Phenyl-2-valerylhydrazine	$C_6H_5NHNHCOC_4H_9$	70	8
1-Isocaproyl-2-phenylhydrazine	$C_6H_5NHNHCO(CH_2)_2CH(CH_3)_2$	73	2
1-Phenyl-2-phenylacetylhydrazine	$C_6H_5NHNHCOCH_2C_6H_5$	76	4
1-Phenyl-2-tolylsulfonylhydrazine	$C_6H_5NHNHSO_2C_6H_4CH_3$	77	0
1-(*p*-Nitrobenzoyl)-2-phenylhydrazine	$C_6H_5NHNHCOC_6H_4NO_2$	78	1
1-Formyl-2-phenylhydrazine	$C_6H_5NHNHCHO$	81	6
1-Phenyl-2-phenylsulfonylhydrazine	$C_6H_5NHNHSO_2C_6H_5$	85	0
1-Phenyl-2-propionylhydrazine	$C_6H_5NHNHCOC_2H_5$	87	0
1-Cinnamoyl-2-phenylhydrazine	$C_6H_5NHNHCOCH:CHC_6H_5$	91	0
1,2-Dibenzoyl-1-phenylhydrazine	$C_6H_6N(COC_6H_5)NH(COC_6H_5)$	91	0
1-Ethoxalyl-2-phenylhydrazine	$C_6H_5NHNHCOCOOC_2H_5$	91	3
Lead arsenate	—	56	6
Check (untreated)	—	92	0

butyryl-2-phenylhydrazine, and 1-phenyl-2-stearoylhydrazine—were relatively close to lead arsenate in their effectiveness.—4-4-46.

DDT to Control Cat and Dog Fleas and Dog Lice

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Fleas, especially the cat flea, *Ctenocephalides felis* Bouché, were very common pests on cats and dogs and in homes in Massachusetts during 1945. Dogs and cats are the sources of flea infestations that commonly bother man in homes in New England. One house infested with the cat flea has come to our notice where it appears that a dog or a cat was not directly responsible for introducing the insect. The people possessed no dog or cat and none had entered the house for some months. This residence was the only one among a number of infested houses treated, where the infestation reappeared during the season. Since the source of the fleas entering the home could not be found and treated, it is presumed both infestations had the same origin. The people living in flea-infested houses often used the term "sand" flea and some were very reluctant to admit or believe that the cat or dog was involved. However, following treatments with DDT dusts, the results have convinced the most skeptical that "sand" was a misnomer. The usefulness of DDT in flea control has been reported in several papers (Anon. 1945a, b, 1946; Knipling, 1944).

The floors and rugs of infested homes were treated with a very light application of 5 or 10 per cent DDT powder. A light application is only sufficient dust, that one can faintly "finger write" in. A clean appearing job is important in treating homes and normal activities of the occupants need not be interfered with. Heavy applications are not essential and the increased visibility from such applications is often embarrassing to the householder. All floors as well as the basement usually were treated. The dust will not harm rugs and was placed on and under them. If the cat or dog slept on the overstuffed furniture, a little dust was applied on such articles. The sleeping blanket, basket, or other equipment used by the pet was treated, as well as any sheltered area about the yard such as underneath porches, under sheds, and in garages if utilized by the infested animal. The dust can be conveniently applied with a plunger type garden duster. A stroke of the plunger of two to four inches was ample to cover a couple of square feet on the floor without raising a dust cloud more than a few inches into the atmosphere of the room. A strong and full stroke of the plunger resulted in an unsightly dust deposit on all articles in the room. In the absence of a duster, a salt or pepper shaker was used. The dust should be sifted onto the floor from a standing position, thus permitting the clumps of dust to scatter before reaching the floor. When properly applied little visible dust was evident. The time required to dust a room with the hand duster was one to two minutes and with the shaker three to four minutes. Regular cleaning of the room should be discontinued for three to four days, after which normal cleaning can be resumed.

The cat or dog should be treated with the same dust at the time or a few hours after treating the floors. The dust was applied with a salt or other shaker along the back of the animal from between the ears to the base of the tail and lightly worked into the hair for a few seconds. Animals with long hair should have a pinch of dust applied to the throat also. A large dog with long hair should receive about a teaspoonful of the dust at a treatment. A mature cat with long hair should receive from one-half to three-fourths of a teaspoonful of the powder. Short-haired, small, and immature animals should receive from one-fourth to one-half as much of the powder at a treatment.

The fleas will become very active on the animal in about 10 to 20 minutes after treatment and because of this activity become correspondingly irritating to the pet. This irritation when the fleas are numerous may cause the dog or cat to become very restless and do considerable scratching with feet and mouth for a time. For this reason the dust should be applied to the cat or dog following treatment of the floors, so that additional fleas will not hop onto the active pet and increase and prolong the irritation. When the fleas are numerous they can frequently be seen on the face and nose of the cat or dog shortly after treatment. It is not necessary to collect and burn the fleas that leave or fall from the treated animal as the fleas do not recover.

Two tests were conducted by treating the hosts without treating the floors. Eight cats were treated in the first instance in a heavily infested home. The result in about 15 minutes was almost explosive. The cats became highly excited by the increased flea activity, and the host activity in turn resulted in more fleas hopping onto the cats. The treated cats were retained in the infested house and remained quite restless for about ten to twelve hours. The owner described the cats as not knowing which place to scratch first. One cat became ill and vomited, apparently as a result of swallowing hair while scratching, rather than from DDT as two fair-sized wads of hair were observed. There was no evidence of illness from the DDT. The day following elimination of the fleas, the cats were very playful and much improved in appearance. The house was treated 3 days later, along with the cats as more fleas were observed on them at this time.

A dog treated by a veterinarian without treating the home showed responses similar to the cats above. He described the dog as frantic, suggesting that it would have used 50 legs in scratching if such had been available. The dog was taken outdoors and was normal after an hour or so and ate a hearty meal. The activity of the dog increased with the flea activity and subsided with elimination of the fleas.

One dog and two kittens were dusted with a 50 per cent DDT water miscible powder. The results were similar to those with the 10 per cent powder. No apparent injury to any of the animals resulted. This concentrated dust is not necessary and is not recommended.

During the 1945 season about twenty infested homes were treated with a 10 per cent DDT powder and a few with a 5 per cent powder with excellent results. A total of twenty cats and nine dogs have been treated with the 10 per cent powder resulting in extermination of all fleas also. A single treatment of the floors and animals sufficed to rid both of fleas when dusted at the same time. One dog was freed of lice by treatment with the 10 per cent powder. The powder was applied lightly to infested parts only, particularly about the head and neck. Applications were made by the owner and apparently three were

necessary to destroy all lice. The powder was applied whenever lice were observed but no record was kept of the interval between treatments.

Applications based on the above recommendations should free a home of flea irritations in a few hours and one thorough treatment of the house should be ample. The cat or dog should be retreated whenever fleas appear on the animal. Reinfestation of the cat or dog occurs from association with infested animals or from visiting flea-infested areas. The powder only because of the simplicity and safety of treatment is recommended for use against flea infestations. The 5 per cent to 10 per cent dust is recommended and powders containing less than 5 per cent DDT are not now recommended.

Some workers have used pyrethrum dust mixed with the DDT on the animals to secure quick killing of the fleas and thus avoiding the irritation resulting from the activity of fleas stimulated by DDT. However, the irritation to the dog or cat will not be serious if the house and premises are treated in advance of treating the animals. The pets do not object to DDT dust as is so frequently true of pyrethrum and rotenone dusts. Several cats became reinfested with fleas 3 to 4 days following treatment with DDT dust when permitted to range over infested territory, thus indicating a short effective residual period.—2-2-46.

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Apple Fruit Worms in Pennsylvania

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Amphipyra pyramidoides Guenée is the most important green fruit worm in Pennsylvania. It is by far more abundant in this State than *Graptolitha antennata* Walk or *G. grotei* Riley, which are so frequently listed as green fruit worms in literature. *A. pyramidoides* feeds more frequently upon the foliage than on the fruit but sometimes does considerable damage to the latter. This species is known under the common name "copper underwing" because of the coppery sheen of the hind wings. It has been reported by various writers from Ampelopsis, apple, grape, chestnut, hickory, lilac, maple, rhododendron, *Vitis*, walnut, wild cherry, willow and witch hazel. However, only two out of six authorities listing the food plants of this species include apple. This species is common throughout the eastern United States and has been found as far west as Colorado. Beutenmüller (1902) describes the larva in considerable detail. It is an easy species to recognize because of the uniform green color, the white lateral line broken at the posterior end, and the dorsal hump on the eighth abdominal segment. Some of the older writers place this species in the genus *Pyrophila*. Three varieties are known; *P. inornata* Grote, *P. conspersa* Riley and the melanistic form *P. carbonata* Francl.

The writer has collected the larvae of *Conistra walkeri* Grote repeatedly from apple and cherry in Pennsylvania, especially from Adams, Centre, Luzerne, Union and Wyoming counties. This species has been reported from apple in Canada but there seems to be no previous record of attacks on fruit in the United States. It is common throughout eastern Canada and the United States from Maine to Iowa and south to Texas. *Viburnum nudum* and oak have been listed as food plants but there may be some confusion of hosts in literature for this species is closely related to *Conistra sidus* Guenée. The writer's material, reared from apple, was determined by Dr. W. T. M. Forbes. The larvae are generally found in early spring feeding upon the buds and unfolding leaves. They have a long pupal period lasting from June of one year until the following spring. When mature they are almost entirely dark velvety red, and the common name red fruit worm is suggested for this species. The larvae have been described in considerable detail by Sanders & Dustan (1919). Older systematists placed this species in the genus *Scopelosoma*.

Morrisonia confusa Hübner has previously been recorded only from willow. The writer reared it from apple. The mature larva is green, about three quarters of an inch long, and has a pale brown head. An adult emerged May 8 from a pupa formed September 1 of the preceding year. This species is apparently common throughout the eastern United States. The larvae have a tendency to web the leaves together while feeding. One synonym, *M. infructuosa* Walk., is known.

A single adult of *Apatela elizabeta* Smith, emerged from a pupa reared on apple. Heretofore no food plants have been recorded for this species. It is more common in southern Pennsylvania and flies from June to August but is generally considered to be rare.

The writer reared *Apatela radcliffei* Harvey from *Amelanchier*. An adult emerged on May 20. This species is known from sugar plum and wild cherry. The larva is described in detail by Beutenmüller (1902). The moths are recorded as flying from April to August.

Apatela fragilis Guenée was also reared from *Amelanchier*. It ramges from Canada to the Carolinas and westward to the Mississippi, and has been reported from apple and mountain ash. Beutenmüller describes the larva in detail. The species has one synonym, *A. spectans* Walk., and a melanistic form, *A. atrior* Francl.

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The Effect of Humidity on the Oviposition Activity of *Macrocentrus ancylivorus*

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Humidity is a very important factor influencing the number of *Macrocentrus ancylivorus* Rohwer bred in potatoes with the potato tuber moth larvae and may frequently mask all other factors bearing upon parasite breeding. The reason for this is that humidity determines the oviposition activity of the parasites. Finney *et al.* (1945) have already discussed another phase of moisture effect upon the number of *M. ancylivorus* bred from potatoes.

Direct observation has shown that when a constant humidity differential of approximately 50 per cent is established in trays, the parasites are very active at the highest humidity level (approximately 80 per cent) and usually they can be observed probing for hosts. At the lowest humidity level (approximately 30 per cent), parasite activity ceases and the adults remain motionless. Normal numbers of parasites were bred in trays with high humidities while very few to none were bred in very dry trays.

When the humidity differential was narrower (the lowest level was approximately 30 and the highest 50 per cent) and the tray humidity fluctuated with the room humidity, as was the case when 25 trays of potatoes with cloth-covered louvers were compared with 25 with 14-mesh screen-covered louvers, three times as many parasites were bred in the trays with cloth-covered louvers. The latter trays maintained more constant and higher humidities than the screen-covered trays where the humidity fluctuated with the room humidity.

All observations were made while the temperature was 80° F.

Such observations indicate that there may be a humidity zone where the numbers of *Macrocentrus ancylivorus* bred, decrease as the relative humidity decreases. Also, when humidity conditions become sufficiently low during the daily fluctuations, oviposition activity may cease to the degree that the humidity depresses activity, and thus decrease the amount of parasitism.

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DDT for the Control of *Triatoma*[1]

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Several species of *Triatoma* occur in Texas which inflict painful bites while feeding upon the blood of humans. These bugs are commonly known as conenoses, bloodsuckers, assassin and kissing bugs. They are also found to be infected with *Trypansoma cruzi*, the causative organism of Chagas' disease. While no cases of this disease have been found in man in Texas it is a common one in South America, mainly in Brazil and Argentina. In this experiment only one Texas species, *Triatoma lecticularius occulta* (Neiva), was used.

[1] Stock solutions of DDT used in this experiment were made available by the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture, Washington, D. C.

Table 1.—Results of cage tests of DDT sprays against *Triatoma*.

No. Bugs	Treatment	Per Cent Mortality Days 1	2	3	4	5	6	7	8
10	1% DDT 1.25% *Tetralin* .25% *B-1956* 97.5% Water	10	60	80	80	90	90	90	100
10	2% DDT 2.5% *Tetralin* .5% *B-1956* 95% Water	30	70	100					
10	5% DDT 6.25% *Tetralin* 1.25% *B-1956* 87.5% Water	30	70	80	100				
10	1% DDT 3% Xylene 1% *Triton X-100* 95% Water	10	90	100					
10	2% DDT 6% Xylene 2% *Triton X-100* 90% Water	20	70	80	80	80	90	100	
10	5% DDT 15% Xylene 5% *Triton X-100* 75% Water	50	90	100					
10	Check No Treatment	0	0	0	0	0	0	0	0

Sprays prepared from stock solutions of DDT were applied to the adult conenose bugs or bloodsuckers, *Triatoma*, to determine the value of the insecticide as a control for these bugs. Valuable results were received from spray applications with as low as 1 per cent DDT. One hundred per cent mortality was obtained from all strengths used (Table 1).

The DDT emulsion was diluted with water and applied directly to the inside areas of the small cages, with a small atomizer sprayer. The insects were kept in these cages throughout the experiments. The cages were improvised by cutting the lower three inches from mailing containers three inches inside diameter. The bottom consisted of metal and the top was covered with bobbinet cloth which was held in place by a rubber band. The bugs were examined and the dead ones removed daily. Each of seven cages contained ten adults of *Triatoma*. All insects were kept in the laboratory at room temperature.—1-21-46.

Insect Infestation in Powdered Hand Soap

R. T. COTTON and J. C. FRANKENFELD, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

The manufacturers of a powdered hand soap recently reported that they have had trouble during the summer from insect infestation in one of their brands of soap. This particular type of soap normally contains 40 per cent of soap and from 50 to 60 per cent of corn meal. Flour beetle infestation in

the corn meal used in manufacturing the soap powder has been the principal source of the trouble.

Owing to the coarseness of corn meal, it is impossible to sift out the eggs and small larvae of insects; therefore, insects present in the milling machinery during the manufacturing process will infest the meal unless it is fumigated, sterilized by heat, or treated with a centrifugal machine. As a precautionary measure, soap manufacturers using corn meal as an ingredient should first render the meal free from insect life by treating it according to one of these methods.

While considering the possibility of adding something to the soap that would make it unattractive to insect life, the attention of the authors was called to the fact that a similar brand of powdered hand soap, differing in formula only by the addition of 3 to 5 per cent of a light-yellow steam-distilled pine oil, did not appear to be infested with insects.

Samples of the soap with and without pine oil were therefore exposed to infestation by the confused flour beetle, *Tribolium confusum* Duv. Twenty-five adult beetles were added to each of duplicate samples of both the powdered hand soap without pine oil and the same soap to which 4 per cent of pine oil had been added. All lots were placed in a constant-temperature room held at 80° F. and a relative humidity of 70 to 80 per cent.

At the end of 30 days not only were all the beetles alive in both samples of the soap containing no pine oil, but numerous eggs and larvae were also present; whereas in one sample of the soap with the pine oil added 96 per cent of the adult beetles were dead at the end of 4 days and 100 per cent at the end of 16 days, and in the second sample 76 per cent were dead at the end of 4 days and 100 per cent at the end of 30 days. No reproduction took place in either of the samples containing pine oil. It is evident that the addition of 4 per cent of pine oil offers a simple solution of the problem of insect infestation in powdered hand soap of this type. Lower percentages of pine oil were not tested.—2-16-46.

A New Record of *Anopheles albimanus* in Texas

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Since *Aonopheles albimanus* Wiedemann is an important vector of malaria in the Caribbean region, its presence in the Lower Rio Grande Valley of Texas has been watched with considerable interest by this department. To date, this mosquito has not been considered of any special significance in malaria transmission there. However, all malaria control projects in the two valley counties, Cameron and Hidalgo, have had as their objective the control of this species in addition to the principal vector of malaria throughout the state as a whole, *A. quadrimaculatus*.

King (1937) reports that the first known record for the state of Texas was by Dyar (1922) in 1928, and that the specimens upon which this record was probably based were labeled from Brownsville, McAllen, and Pharr, Texas, collected during October and November, 1923 by R. L. Turner. The first *Anopheles albimanus* now in the Texas State Health Department collection were taken by T. McGregor from Hidalgo County May 31, 1937 and Cameron County July 10, 1937. Since that time this species has been taken in large numbers from the area immediately adjacent to Brownsville during all but the coldest of the winter months. Up the valley into Hidalgo County a marked decrease in *A. albimanus* populations has been observed.

Until November 1945, there has apparently been no tendency for this *Anopheles* to migrate into the interior of the state. On November 1, 1945, a single female was taken from a New Jersey type light trap at Waldron Field, an auxillary field 5 miles from the Naval Air Station, Corpus Christi, Texas, and 150 miles from Brownsville, Texas. It was thought that the one specimen could have been introduced by plane or automobile. However, there are no regular flights to the valley from Corpus Christi, other than commercial.

The possibility of accidental introduction was reduced by the collection of four other female specimens from light traps. One specimen was taken November 10, 1945, from the South gate area of the main Naval Air Station, two more at Waldron Field, November 10, 1945, and one from Cabaniss Field, November 8, 1945, twelve miles from the main Naval Air Station.

As our light trap records have never indicated that *Anopheles albimanus* is strongly attracted to light, the assumption appears justified that a considerably larger number of adults were present in the area. A preliminary survey revealed no larvae of this species and before a careful search could be made the entire area was sprayed with a 5 per cent DDT solution by plane, with a resultant drastic reduction in both mosquito adults and larvae. Since November no *A. albimanus* have been found.

SUMMARY.—Five *Anopheles albimanus* females were taken within a two-week period from three different locations near the Corpus Christi Naval Air Station. This represents the first known migration of this species from the Lower Rio Grande Valley into other parts of Texas.—1-21-46.

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The death of Norwood A. Eaton, a graduate of the University of Maryland in 1927, has recently occurred. Mr. Eaton was attached to the department of entomology where his major work was done.

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What's in a Name?

AN INEVITABLE concomitant of the recent rapid development of a large number of new insecticides is a confusion in the names of these new products.

Relatively few of the substances formerly used as insecticides were new or were developed primarily for use as such; they were rather materials of long standing which had been at various times employed in insect control. And they were, almost without exception, the property of the public, of known composition and bearing established common names. It is true that these common names were at the same time the chemical names of the substances and indicated their chemical composition. But often there was a common name which had been adopted by the chemists and the public and which had no technical connection.

Manufacturers marketing such products might identify their products by use of their firm names or by trade-marked names, but these were almost always accompanied by the common name already known to the public and when they were not it was usually easy to substitute the chemical or common name for the trade name. There was never any secret connected with the name *Black-leaf 40;* it was identified as 40 per cent nicotine sulphate by the manufacturers; and nicotine sulphate, while a chemical designation, was simple enough so that it presented no difficulty to the ordinary user of the material. The same was true of almost all other insecticides. A few exceptions gradually were developed but not so fast that they could not be absorbed into our vocabularies.

Even dinitro-ortho-cyclohexylphenol was swallowed, albeit with some difficulty, by entomologists and fruit growers and it soon acquired an abbreviation which simplified its use.

The advent of DDT will long remain a landmark in the history of insecticides, not only because of the profound importance of that substance itself but also because it signalized the development of many other wholly new synthetic chemicals which may be expected to establish themselves in the insecticide field. Being wholly new, these chemicals do not have even chemical names, in many instances. They have rather, chemical descriptions, awkward even for the chemist and impossible for the public.

Inventors, discoverers or manufacturers of these substances have often provided abbreviated names or trade names for the materials. These might solve the difficulties, as was true earlier, if they were designed to serve as chemical names for the insecticides. For DDT we may say this is true; for some of the others, benzene hexachloride for instance, an acceptable chemical name serves as a common name. But for many others we have merely the chemical *description* and one of several trade names which are applied to the chemical or to some insecticidal formulation based on the chemical.

There is no particular difficulty connected with a trade-marked name for an insecticide provided the chemical name is available and can be substituted for it. Such names may even serve a very useful purpose but they are subject to one grave objection in too many cases. That is the fact that they are trade-marked and can be used by one manufacturer only. Where only one manufacturer can produce the insecticide the situation is not impossible. But where it may be produced by many different firms, each of which uses its own name for the material, confusion enters. If there is a basic, unrestricted common name, as DDT, there still may be confusion because of the varied formulations on the market, each one bearing some distinctive trade name which tends distinctly to promote confusion in the use of the basic material, whether it be in research or in actual control operations.

With DDT the situation is not so bad

as it threatens to become with other new materials because we can insist on the use of DDT along with any qualifying name which may be added to identify the manufacturer and his distinctive formulation. But other materials have jumped directly from the chemical description, often a combination of numerals, initials, qualifying syllables and greek letters, topped off by a polysyllabic jawbreaker, to a variety of trade names all referring to some form of the same basic material. The investigator, having no recourse, must use the chemical description or the manufacturers trade-marked name. His results should be in such form, when published, that they may be readily compared with those of any other investigator using the same material. But the second man got his supply from a different manufacturer who has his own trade name. And the reader of the reports does not know that KDKA and WEAF refer to the same basic chemical. Later, reference works will identify the materials but they are not available yet and will never solve the difficulty entirely.

A recent group of papers to be published in the *Journal* brought the difficulty out in a very striking manner. One paper bore a footnote to a table in which 21 different materials mentioned in the table were given further identification; information which was necessary if the reader was to have the information clearly presented.

The first reaction of the editor was that the *Journal* must "clamp down" on its rules concerning the use of trade names. (The rules followed, so far as possible, in the *Journal* are clearly stated in the report of the Committee on Insecticide Nomenclature, published in the report of the Dallas meetings.) But it soon became evident that the rules could not be followed to the letter; in tables the difficulties were insurmountable. Readers will recognize confusion in the usage and doubtless will find plenty of reason to criticize. If this leads to *constructive* criticism, progress may be expected. In the meantime confusion will continue.

In the opinion of the writer the difficulty can be solved in only one way. We must have acceptable common names, chemical names and not chemical descriptions, perhaps, or just arbitrary common names which shall identify the chemical, without regard to the manufacturer. Names which shall, like DDT, be available to all who wish to use them and which should form a part of each and every trade name for the substance.

We suggest that our Committee on Insecticide Nomenclature be empowered and instructed to formulate such names where they are obviously needed, and submit them at annual meetings of the Association for approval. The committee will, naturally secure all the cooperation it may wish to use; other members, insecticide manufacturers and other interested in use of insecticides, all will see that it is to their interest to cooperate. It is entirely possible that some manufacturers who control established trade names under the trade-mark restrictions, may see fit to release some of these for general use.

As fast as such names are approved it will become the policy of the *Journal* as already provided by the Association, to insist on their use. And let it be understood that the function of the committee is to be constructive and aggressive, not passive. That the committee is supposed to get out and "dig up" good common names where they are needed, not to wait until someone happens to suggest them.

The final word on the subject, at this time, concerns the form of names which is most serviceable, and suggestions along this line must be negative rather than positive. Naturally appropriate names are desirable; names which suggest some clue to the nature of the material. But they are not always possible. On the other hand names which are undesirable, at least from the editorial point of view, may be pointed out. First, numerals, not preceded by letters or, better, syllables, are bad. For instance "*1080*" should not be allowed to persist. The reason is simple; it is impossible to index such names in an alphabetical index. *Six-six-six* might be all right, but *666* should not be allowed to establish itself.

Initials only, are to be questioned. A few such names may be all right; DDT for instance; but when we get DDD and other closely similar forms confusion results. The committee may be trusted to take all such factors into consideration.

Where it is possible to get a very simple form of the actual chemical name, that is to be preferred to any other common name.

OBITUARIES

Benjamin H. Walden, 1879–1946

Benjamin H. Walden, for 43 years Assistant Entomologist at the Connecticut Agricultural Experiment Station and a member of the American Association of Economic Entomologists since 1904, died January 6, 1946, three months after he had retired. He graduated from the Connecticut Agricultural College (now the University of Connceticut) in 1900 and for a short time thereafter worked for the Bureau of Entomology in Washington, D. C. He joined the staff of the Connecticut Station on March 1, 1902, and was continuously employed until October 1, 1945, when ill health forced him to give up his work.

During his long and useful career, Mr. Walden worked in many fields of economic entomology. He assisted Doctor Britton, the entomologist, in field experiments for the control of the San José scale early in the history of the ravages of that insect, and these two collaborated in a series of experiments in the control of white pine weevil and certian other pests. Later Mr. Walden studied the biology and control of a number of agricultural and household insects and carried out a series of fumigation experiments. At times he aided in nursery inspection and gypsy moth control, and for a few years was in charge of mosquito control in Connecticut. In all this he proved a careful and precise worker. In the field of taxonomy and identification, he showed considerable ability. The insect collection at the Experiment Station was under his care. He was an authority on Orthoptera and Hemiptera, and in 1911 published "The Euplexoptera and Orthoptera of Connecticut," a bulletin of the Connecticut Geological and Natural History Survey. His skill at photography is attested by the illustrations in the publications of the Department of Entomology.

Mr. Walden always exemplified those personal qualities which endeared him to his colleagues and friends. He was modest and unassuming, yet helpful, particularly so to younger members of the staff. Endowed with uncompromising integrity and loyalty, he displayed an admirable forthrightness at all times. We appreciated not only his professional skill, but also that inherently decent character which made our association so pleasant.

BENJAMIN H. WALDEN

He is survived by his wife, one son, three daughters, a brother, and five grandchildren.

R. B. FRIEND

Dr. Grace H. Griswold, 1872-1946

Dr. Grace H. Griswold, since 1918 a member of the staff of the Department of Entomology, Cornell University, and an authority on household insects, died the 22nd of January, 1946. Earlier in the winter a severe attack of influenza left her in a weakened condition, but in spite of this she returned to her work in the laboratory. On the day of her death she had lunch with some friends, apparently in her usual good spirits. Her sudden demise a few hours later therefore came as a great shock to her colleagues and many friends.

Miss Griswold was the daughter of the late Dr. Joseph B. Griswold, who for many years was a prominent physician in Grand Rapids, Michigan. She was born in Taylors Falls, Minnesota, December 14, 1872, but came to Grand Rapids with her parents the following year. While a resident of that city she was an enthusiastic gardener, was one of the founders of the Kent Garden Club and its first secretary. Upon the death of her father in 1915, she entered Cornell University as a student of Landscape Architecture, graduating from the university in the fall of 1918.

Being aware of the many insects which infest the flower garden she turned her attention to the study of entomology, entered upon graduate work in the subject and received the degree of Doctor of Philosophy from Cornell University in 1925. She was appointed a research instructor in the Department of Entomology, making a special study of insects that attack ornamental plants and of those infesting the household. The results of her various studies have been published in several bulletins of the Cornell University Experiment Station and in articles which have appeared in entomological journals.

Although officially she retired in 1941 she continued regularly to spend several hours a day in the laboratory engaged in writing up the results of her

experiments and in building up a collection of aphids injurious to ornamental plants. Beginning her entomological career much later than most, by her industry and enthusiasm she established an enviable reputation as an authority in her special field. Her published papers demonstrate in their form and substance the meticulous care with which they were prepared.

She spared no effort in being helpful to the women students in whom she took a strong personal interest. A woman of strong character, with firm convictions, and outspoken, she was kindly, friendly, and co-operative.

She was a fellow of the American Association for the advancement of Science and of the entomological Society of America; a member of the Association of Economic Entomologists, and of the honorary societies Sigma Xi and Sigma Delta Epsilon.

By her death the members of the Department of Entomology have lost a faithful colleague, her associates a devoted friend, and the University a loyal supporter.

O. A. JOHANNSEN

MEDAL AWARDED DR. KNIPLING BY UNITED STATES TYPHUS COMMISSION

Mr. Edward F. Knipling, Entomologist, Bureau of Entomology and Plant Quarantine, a member of this Association since 1931, was presented with the United States Army Typhus Commission Medal on 13 May 1946.

As Senior Entomologist, in charge of the Bureau's Orlando, Florida, laboratory, Mr. Knipling helped develop methods for the control of insects which affect the health of man. Mr. Knipling said, upon receiving the medal from Secretary of Agriculture Clinton P. Anderson, "I'm glad to accept this medal, Mr. Secretary, in recognition to all of the members of the group of men who have done the work. We have all worked together as a team and the combined effort of this team made this award possible." Mr. Knipling and his associates developed or adapted practically all of the insecticides and repellents used by the armed services during World War II. The Typhus Medal was awarded to Mr. Knipling for his contributions toward the control of insects which transmit typhus. Among the products developed or adapted by the Orlando laboratory were DDT compounds which gave almost complete control over the body louse which transmits the disease in epidemic form, "6-2-2" as a repellent, and benzylbenzoate for the control of mites that carry scrub typhus to man.

The citation read "These studies, enlarging scientific knowledge, led to the effective use of DDT in the control of epidemic typhus fever. Mr. Knipling's contributions served as a basis for preventive measures which were highly effective in protecting troops from disease and in controlling epidemics among civilian populations."—6-5-46.

SECRETARY ANDERSON, MR. KNIPLING AND GENERAL S. BAYNE JONES

Symposium—Toxicity of DDT

A symposium on the Toxicity of DDT and the Hazards Involved in the Agricultural Use of DDT was held at the National Academy of Sciences Building in Washington on May 24, 1946 under the auspices of the Biology Subcommittee of the National Research Council Insect Control Committee. Although the railroad strike which began the day before prevented the participation of a number of interested individuals, the meeting was well attended by representatives from the Bureau of Entomology and Plant Quarantine, Bureau of Animal Industry, Food and Drug Administration, National Institute of Health, United States Public Health Service, State Experiment Stations and Colleges, and by Pharmacologists working independently of state and federal agencies, various liaison representatives, and men from insecticide industries nominated by the offices of AIFA and NAIDM.

The toxicity of DDT was discussed by Dr. McKeen Cattell, Cornell Medical College, Dr. Paul Neal of the National Institute of Health and Dr. John H. Draize of the U. S. Food and Drug Administration. The hazards in the agricultural use of DDT were discussed by Dr. George C. Decker, University of Illinois. The following represents a brief summary of the material discussed.

The acute oral toxicity of DDT judged by tests on laboratory animals is so low that fatal cases of DDT poisoning by mouth can be expected only in cases of gross carelessness or by deliberate attempts at suicide. Moreover, even in such cases, solvents commonly used for DDT are much more toxic than the DDT. Even if DDT is ingested accidentally, prompt action in washing out the stomach and the administration of therapeutic agents will mitigate the danger.

There is practically no danger involved in the exposure of individuals to aerosols or dusts when these are used as directed and the usual precautions are taken.

Chronic toxicity tests on laboratory animals indicate that when DDT dosages of reasonably large magnitude are incorporated into the diet, toxic symptoms characteristic of DDT may result. These include hyperexcitability, tremors, and liver lesions. In these cases the DDT may accumulate in the fat reserves of the animal. If the feeding of DDT is terminated, the DDT may be slowly released from the fat and excreted, chiefly as the acetic acid derivative of DDT. If, however, the animal is starved after the feeding period, the DDT is released from the fat rapidly enough to cause toxic effects.

The hazards involved in the agricultural use of DDT involve not so much accidental ingestion of large quantities of DDT or the continued exposure of personnel employed in spraying operations, but rather the possibility of cumulative effects due to the continued eating of fruits and vegetables treated and of milk products and fat meat from animals which have fed on forage crops treated with DDT. The importance of this problem was emphasized by Dr. Decker as follows: "The decision to be made in some cases is of greater importance than some people realize. Wherever the residue hazard is known to be real and not a remote possibility there is no question what action should be taken. On the other hand, the United States has encountered difficulty in fulfilling its commitments for food to be shipped abroad. Our food reserves have been depleted and we are asked to tighten our belts. The supply of nearly every insecticide used in Amreica is short. Rotenone and nicotine are practically unavailable and yet if our farmers are to produce maximum crops so that Americans will not be hungry and Europeans starve, insect pests must be controlled. In such an emergency the use of DDT on crops where the residue problem would be negligible or at least remote should not only be sanctioned but should be encouraged. Otherwise the remote possibility that some individual man or animal may suffer is balanced against the probability that many will suffer hunger or perhaps death due to starvation."

Our greatest lack of information appears to be in regard to the chronic toxicity of DDT which might result from dosages at residue levels. To supply this information, entomologists and chemists should determine: the deposits of DDT found on plants immediately after treatment at known rates of application, the decomposition or loss of DDT from the plants, the residues obtained at harvest time following various practical spraying or dusting schedules, and the possible value of neutralizing or decontaminating sprays, if such are needed. The toxicologists and chemists should determine the effect of DDT at residue levels on animals and animal products. A stumbling block in the progress along this line appears to be the inadequacy of facilities for analyzing for DDT at residue levels on agricultural products. The suggestion was made at the meeting that it would be desirable to explore the possibility of cooperation between the manufacturers of DDT and others interested in this problem with a view to pooling their resources in the establishment of laboratories where research workers might submit samples for analysis.

Copies of the minutes of this meeting may be obtained as long as the supply lasts by writing to the Insect Control Committee, National Research Council, 2101 Constitution Avenue, Washington 25, D. C.—R. L. Beard.

The Stalk Borer Attacking Raspberries

Recently while examining a plot of red raspberries it was noted that there was a considerable amount of twig injury on the current season's canes. An examination of the injured twigs revealed the presence of the stalk borer, *Papaipema nebris* (Guen.). The injury was in the terminal 5 or 6 inches of the cane. Six larvae were found, these varied considerably in size. The largest was nearly full grown, others only about a half inch long. F. R. Shaw.

Recent Address Changes

Mr. H. A. Madden, formerly located at the Bureau Laboratory in Orlando, Florida, may now be addressed Box 97, Lithopolis, Ohio, and Mr. A. W. Lindquist, of the same laboratory is in Portland, Oregon, present address c/o C. M. Gjullin, 438 U. S. Courthouse. We hope to have more informative notes on these members in the next issue of the Journal.

We are informed also that Dr. Knipling is to have a new address in Texas in the near future.

NOTICES TO READERS

The completely revised list of Common Names of Insects Approved by the American Association of Economic Entomologists and the Entomological Society of America is to be published in the August issue of the JOURNAL. Advance orders for reprints may be placed with the Business Manger of the JOURNAL, Dr. E. N. Cory, now and will guarantee receipt of reprints and also serve as an indication of the number which should be printed.

Classified Advertisements are now limited to ten lines. The charge is 50 cents per issue or $2.50 per year.

Individuals who make application for membership in this Association in the regular form will have their applications acted upon at the annual meeting in December. Even though the application and accompanying check may be received early in the year, applicants do not receive the JOURNAL on a membership basis until after their applications have been approved by the Association. The names of new members are entered upon the mailing list for the February, or No. 1, number of the new volume and subsequent issues. If they want the JOURNAL for the current year in which they have made application, they should forward $4.00 for a non-membership subscription. This statement is made to clear up a misconception that apparently occurs occasionally in the minds of some of the older members and frequently in the minds of the applicants.—E.K.C.